

EXPERT REPORT OF JOWEI CHEN, Ph.D.

April 8, 2019

I am an Associate Professor in the Department of Political Science at the University of Michigan, Ann Arbor. I am also a Research Associate Professor at the Center for Political Studies of the Institute for Social Research at the University of Michigan and a Research Associate at the Spatial Social Science Laboratory at Stanford University. In 2007, I received a M.S. in Statistics from Stanford University, and in 2009, I received a Ph.D. in Political Science from Stanford University. I have published academic papers on legislative districting and political geography in several political science journals, including *The American Journal of Political Science* and *The American Political Science Review*, and *Election Law Journal*. My academic areas of expertise include legislative elections, spatial statistics, geographic information systems (GIS) data, redistricting, racial politics, legislatures, and political geography. I have expertise in the use of computer simulations of legislative districting and in analyzing political geography, elections, and redistricting.

I have authored expert reports in the following redistricting court cases: *The League of Women Voters of Florida et al. v. Ken Detzner et al.* (Fla. 2d Judicial Cir. Leon Cnty. 2012); *Rene Romo et al. v. Ken Detzner et al.* (Fla. 2d Judicial Cir. Leon Cnty. 2013); *Missouri National Association for the Advancement of Colored People v. Ferguson-Florissant School District and St. Louis County Board of Election Commissioners* (E.D. Mo. 2014); *Raleigh Wake Citizens Association et al. v. Wake County Board of Elections* (E.D.N.C. 2015); *Corrine Brown et al. v. Ken Detzner et al.* (N.D. Fla. 2015); *City of Greensboro et al. v. Guilford County Board of Elections* (M.D.N.C. 2015); *Common Cause et al. v. Robert A. Rucho et al.* (M.D.N.C. 2016); *The League of Women Voters of Pennsylvania et al. v. Commonwealth of Pennsylvania et al.* (No. 261 M.D. 2017); *Georgia State Conference of the NAACP et al. v. The State of Georgia et al.* (N.D. Ga. 2017); *The League of Women Voters of Michigan et al. v. Ruth Johnson et al.* (E.D. Mich. 2017); and *William Whitford et al. v. Beverly Gill et al.* (W.D. Wis. 2018). I have testified either at deposition or at trial in the following cases: *Rene Romo et al. v. Ken Detzner et al.* (Fla. 2d Judicial Cir. Leon Cnty. 2013); *Missouri National Association for the Advancement of Colored People v. Ferguson-Florissant School District and St. Louis County Board of Election Commissioners* (E.D. Mo. 2014); *Raleigh Wake Citizens Association et al. v. Wake County Board of Elections* (E.D.N.C. 2015); *City of Greensboro et al. v. Guilford County Board of*

Elections (M.D.N.C. 2015); Common Cause et al. v. Robert A. Rucho et al. (M.D.N.C. 2016); The League of Women Voters of Pennsylvania et al. v. Commonwealth of Pennsylvania et al. (No. 261 M.D. 2017); Georgia State Conference of the NAACP et al. v. The State of Georgia et al. (N.D. Ga. 2017); The League of Women Voters of Michigan et al. v. Ruth Johnson et al. (E.D. Mich. 2017); and William Whitford et al. v. Beverly Gill et al. (W.D. Wis. 2018). My Curriculum Vitae is attached as an exhibit to this report. I am being compensated \$500 per hour for my work in this case.

Research Question and Summary of Findings

The attorneys for the plaintiffs in this case asked me to analyze the legislative districting plans enacted in 2017 for North Carolina's House of Representatives and Senate districts (the "2017 House Plan" and the "2017 Senate Plan"). Specifically, I was asked to analyze:

- 1) Whether partisan intent was the predominant factor in the drawing of the 2017 House and 2017 Senate Plans, both at a statewide level and with respect to certain county groupings.
- 2) The effect of the enacted plans on the number of Democratic and Republican legislators elected from North Carolina, both at a statewide level and with respect to certain county groupings;
- 3) The extent to which the 2017 House and 2017 Senate Plans conform to the "2017 House and Senate Plans Criteria" adopted by the House and Senate Redistricting Committees (the "2017 Adopted Criteria"), with the exception of the criterion regarding political considerations, and relatedly, the extent to which partisan intent subordinated these Adopted Criteria.
- 4) The effect of the enacted plans on the partisan composition of the individual plaintiffs' House and Senate districts.

In conducting my academic research on legislative districting, partisan and racial gerrymandering, and electoral bias, I have developed various computer simulation programming techniques that allow me to produce a large number of non-partisan districting plans that adhere to traditional districting criteria using US Census geographies as building blocks. This simulation process ignores all partisan and racial considerations when drawing districts. Instead, the

computer simulations are programmed to optimize districts with respect to various traditional districting goals, such as equalizing population, maximizing geographic compactness, and preserving political subdivisions such as county, municipal, and precinct boundaries. By randomly generating a large number of districting plans that closely adhere to these traditional districting criteria, I am able to assess an enacted plan drawn by a state legislature and determine whether partisan goals motivated the legislature to deviate from these traditional districting criteria. More specifically, by holding constant the application of non-partisan, traditional districting criteria through the simulations, I am able to determine whether the enacted plan could have been the product of something other than the intentional pursuit of partisan advantage. With respect to North Carolina's 2017 House and 2017 Senate Plans, I determined that it could not.

I use this simulation approach to analyze North Carolina's 2017 House and 2017 Senate Plans in several different ways:

Statewide Plan Results: First, I conduct an initial set of 1,000 independent simulations for each chamber, instructing the computer to generate legislative districting plans that strictly follow the traditional districting criteria within the Adopted Criteria (i.e., population equality, geographic compactness, contiguity, respecting county groupings, and preserving municipal and precinct boundaries). These simulations, which follow only non-partisan districting criteria, are referred to as House Simulation Set 1 and Senate Simulation Set 1. I then measure the extent to which the 2017 House Plan and the 2017 Senate Plan deviate from these simulated plans with respect to the non-partisan portions of the Adopted Criteria. The simulation results demonstrate that the enacted 2017 House and Senate Plans both split far more precincts and municipalities than is reasonably necessary. Both enacted plans' districts are also significantly less geographically compact than the computer-simulated districts. By either measure of compactness specified in the 2017 Adopted Criteria (i.e., Reock and Polsby-Popper), the 2017 House Plan is significantly less compact than every single one of the 1,000 simulated House districting plans, and the 2017 Senate Plan is significantly less compact than every single one of the 1,000 simulated Senate districting plans.

By significantly subordinating these non-partisan, traditional districting criteria of geographic compactness and preserving municipal and precinct boundaries, the 2017 House Plan was able to create a total of 78 Republican-leaning districts (out of a total of 120 districts), as

measured using results from the ten historical elections that the General Assembly considered in 2017 according to the Adopted Criteria; the 2017 Senate Plan was able to create a total of 32 Republican-leaning districts (out of a total of 50 districts), as measured using the results of these ten historical elections. By contrast, the simulation results demonstrate that a map-drawing process adhering strictly to non-partisan, traditional districting criteria consistently creates plans with more Democratic districts and fewer Republican districts. Every one of the 1,000 simulated plans in House Simulation Set 1 creates fewer Republican-leaning districts than the enacted 2017 House Plan, and every one of the 1,000 plans in Senate Simulation Set 1 creates fewer Republican-leaning districts than the enacted Senate plan. Thus, 2017 House Plan and the 2017 Senate Plan are both extreme statistical outliers, creating levels of partisan bias never observed in a single one of the 1,000 computer-simulated plans for each chamber. Both enacted plans create more Republican seats and fewer Democratic seats than what is generally achievable through a map-drawing process that adheres solely to non-partisan, traditional districting criteria. The simulation results thus warrant the conclusion that partisan considerations predominated over non-partisan districting criteria, particularly geographic compactness and minimizing municipality and precinct splits, in the drawing of the 2017 House Plan and the 2017 Senate Plan.

Incumbency Protection: Having found that partisan considerations predominated in the drawing of the 2017 House Plan and the 2017 Senate Plan, I then conducted a separate analysis to evaluate whether an attempt to protect incumbent legislators in North Carolina's House and Senate delegation might explain the partisan bias in the two enacted plans. The Adopted Criteria defined "Incumbency Protection" as "avoid[ing] pairing incumbent members of the House or Senate with another incumbent," and I employ that definition. As detailed later in this report, I identified every district in the current districting plans for which the incumbent was protected (i.e., not paired with another incumbent) at the time the district was created. Although the protection of incumbents is not a traditional districting principle, I nevertheless analyzed whether an intentional effort to protect these incumbents somehow altered the partisan composition of districting plans and explains the Republican advantage exhibited by the 2017 House and Senate Plans.

I therefore conducted a second set of 1,000 House simulations and 1,000 Senate simulations by instructing the computer to produce districting plans that intentionally protect the

mathematically maximum possible number of incumbents within each county grouping. I also instructed the simulation algorithm to protect the very same set of incumbents who were protected in the 2017 House Plan and the 2017 Senate Plan, while otherwise adhering strictly to the non-partisan districting criteria specified in the 2017 Adopted Criteria (i.e., population equality, geographic compactness, contiguity, respecting county groupings, and preserving municipal and precinct boundaries). These simulations, which protect incumbents while otherwise following non-partisan districting criteria, are referred to as House Simulation Set 2 and Senate Simulation Set 2.

Analysis of these two sets of simulations demonstrates that an effort to avoid pairing incumbents does not explain the extreme Republican bias exhibited by the enacted plans. Among the 1,000 simulated House plans in House Simulation Set 2, not a single plan exhibits the same extreme level of Republican bias as the enacted House plan; instead, every simulated plan has fewer Republican and more Democratic districts. Similarly, among the 1,000 simulated Senate plans in Senate Simulation Set 2, not a single plan exhibits the same extreme level of Republican bias as the enacted Senate plan; instead, every simulated plan produces fewer Republican and more Democratic districts. These simulation results clearly disprove any notion that an effort to avoid pairing incumbents can explain the extreme partisan bias observed in the 2017 House Plan and the 2017 Senate Plan.

County Grouping-by-Grouping Analysis: I also evaluate the extent to which partisan intent predominated in the drawing of districts within particular county groupings, as drawn under the 2017 House and 2017 Senate Plans. Using both sets of 1,000 simulated House plans described above (House Simulation Set 1 and House Simulation Set 2), I compared the 2017 House Plan's version of districts within a particular county grouping to the entire distribution of computer-simulated districts in that same grouping. These comparisons allowed me to identify the particular groupings in the 2017 House Plan that are partisan outliers compared to the computer-simulated versions of that same grouping. Using this methodology, as described in detail later in this report, I found that the 2017 House plan contains partisan outlier districts within the following 15 House county groupings:

1. The Alamance County grouping
2. The Anson-Union County grouping
3. The Brunswick-New Hanover County grouping

4. The Buncombe County grouping
5. The Cabarrus-Davie-Montgomery-Richmond-Rowan-Stanly County grouping
6. The Cleveland-Gaston County grouping
7. The Columbus-Pender-Robeson County grouping
8. The Cumberland County grouping
9. The Duplin-Onslow County grouping
10. The Forsyth-Yadkin County grouping
11. The Franklin-Nash County grouping
12. The Guilford County grouping
13. The Lenoir-Pitt County grouping
14. The Mecklenburg County grouping; and
15. The Wake County grouping.

For the Senate, using both sets of 1,000 simulated Senate plans described above (Senate Simulation Set 1 and Senate Simulation Set 2), I compared the 2017 Senate Plan's districts within a particular county grouping to the entire distribution of computer-simulated districts produced within the same grouping. As described in detail later in this report, I found that the 2017 Senate plan contains partisan outlier districts within the following seven Senate county groupings:

1. The Alamance-Guilford-Randolph County grouping
2. The Bladen-Brunswick-New Hanover-Pender County grouping
3. The Buncombe-Henderson-Transylvania County grouping
4. The Davie-Forsythe County grouping
5. The Duplin-Harnett-Johnston-Lee-Nash-Sampson County grouping
6. The Franklin-Wake County grouping; and
7. The Mecklenburg County grouping.

In summary, I found many county groupings across North Carolina in which the 2017 House Plan and the 2017 Senate Plan contain partisan outlier districts when compared to computer-simulated plans that emerge from a partisan-neutral simulation algorithm. Furthermore, I found that a map-drawing process protecting the maximum possible number of incumbents within these county groupings, while otherwise adhering to non-partisan districting criteria, does not cause or explain the enacted plans' many partisan outlier districts in these 15

county groupings in the 2017 House Plan or in these seven county groupings in the 2017 Senate Plan.

Finally, to evaluate the partisan effect of the 2017 House Plan and the 2017 Senate Plan on individual plaintiffs in this litigation, I evaluate plaintiffs' districts, both in the computer-simulated plans produced for this report and in the 2017 House Plan and 2017 Senate Plan. Specifically, I compare the partisanship of plaintiffs' districts under the 2017 House and 2017 Senate Plan to the partisanship of plaintiffs' districts under the computer-simulated House and Senate plans. As described near the end of this report, I find that many individual plaintiffs live in House and/or Senate districts that are extreme outliers in their partisan composition compared to the districts those plaintiffs would live in under the computer-simulated plans.

The Logic of Districting Simulations

Once a districting plan has been drawn, academics and judges face a challenge in assessing the intent of the map-drawers, especially regarding partisan motivations. The central problem is that the mere presence of partisan bias may tell us very little about the intentions of those drawing the districts. Whenever political representation is based on winner-take-all districts, asymmetries between votes and seats can emerge merely because one party's supporters are more clustered in space than those of the other party. When this happens, the party with a more concentrated support base achieves a smaller seat share because it racks up large numbers of "surplus" votes in the districts it wins, while falling just short of the winning threshold in many of the districts it loses. This phenomenon, which I have described in my academic work,¹ can happen quite naturally in cities due to such factors as racial segregation, housing and labor markets, transportation infrastructure, and residential sorting by income and lifestyle.

In creating the 2017 Plans, the General Assembly announced that it would rely on ten statewide elections from 2010-2016, including statewide elections for US President, US Senator, Governor, Lieutenant Governor, and Attorney General. Tallying the results of these ten elections across the state shows that Democratic candidates won 47.92% of the overall two-party votes in these ten statewide contests. Yet, tallying the results of these same ten statewide election contests

¹ Jowei Chen and Jonathan Rodden, 2013. "Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures" *Quarterly Journal of Political Science*, 8(3): 239-269; Jowei Chen and David Cottrell, 2016. "Evaluating Partisan Gains from Congressional Gerrymandering: Using Computer Simulations to Estimate the Effect of Gerrymandering in the U.S. House." *Electoral Studies*, Vol. 44, No. 4: 329-430.

district by district, Democratic candidates received more votes than Republican candidates in only 18 of 50 districts (36%) in the 2017 Senate Plan and in only 42 of 120 districts (35%) in the 2017 House Plan. In other words, the percentage of districts that are Democratic-favoring in each enacted plan is significantly lower than the Democrats' share of the statewide two-party vote in recent elections.

The crucial question is whether this skewed distribution of partisan outcomes created by the 2017 House Plan and the 2017 Senate Plan could have plausibly emerged from a non-partisan redistricting process and thus could be explained by non-partisan factors, such as a clustering of Democratic voters in large cities. To assess this question, one must compare the General Assembly's enacted districting plans to a standard based on a neutral districting process that follows the non-partisan redistricting criteria specified in the 2017 Adopted Criteria.

The computer simulations I conducted for this report have been created expressly for the purpose of developing such a standard. Conducting computer simulations of the districting process is the most statistically accurate strategy for generating a baseline against which to compare an enacted districting plan, such as the 2017 House and Senate Plans. The computer simulation process ignores any data regarding partisanship or racial demographics. Instead, the computer algorithm generates a large number of complete districting plans adhering strictly to the non-partisan portions of the 2017 Adopted Criteria. The districting simulation process uses precisely the same Census geographies and population data that the map-drawer used in creating the enacted districts. In this way, the districting plans that emerge from these computer simulations are based on, and thus account for, the very same population patterns and political boundaries across North Carolina that the General Assembly faced when drawing the 2017 Plans. If the geographic and population patterns of North Carolina voters naturally favor one party over the other, then the simulated plans would capture such inherent geographic and demographic bias.

I use the computer algorithm described above to generate 1,000 simulated House plans and 1,000 Senate plans in Simulation Set 1, adhering strictly to the non-partisan portions of the 2017 Adopted Criteria. Each simulated plan combines North Carolina's census geographies together in a different way, but always in compliance with the non-partisan districting criteria that the computer has been programmed to follow. The simulations thus produce a large distribution of non-partisan districting plans drawn solely on the basis of the non-partisan

portions of the 2017 Adopted Criteria. Later, I generate an additional 1,000 simulated House plans and 1,000 Senate plans in Simulation Set 2 by maximizing the protection of incumbents within each county grouping while otherwise adhering to the non-partisan portions of the 2017 Adopted Criteria.

To measure partisan performance under each of these computer-simulated plans, I used actual election results from statewide elections in North Carolina. During the 2017 redistricting process, Representative David Lewis announced at the House Redistricting Committee's August 10, 2017 meeting that the General Assembly would use the following ten statewide elections in creating the 2017 Plans: The 2010 US Senate election, the 2012 US President, Governor, and Lieutenant Governor elections, the 2014 US Senate election, and the 2016 US President, US Senate, Governor, Lieutenant Governor, and Attorney General elections.

I obtained an electronic file detailing the results of these ten 2010-2016 election contests at the census block level. I aggregated these block-level election results to the district level within each simulated plan, and I calculated the number of districts that would have been won by Democrats and Republicans under each districting plan. I use these calculations to measure the partisan performance of each simulated plan analyzed in this report. In other words, I look at the census blocks that would comprise a particular district in a given simulation and, using the actual election results from those census blocks, I calculate whether voters in that simulated district collectively cast more votes for Democratic or Republican candidates in the 2010-2016 statewide election contests. I performed such calculations for each district under each simulated plan to measure the number of districts Democrats or Republicans would win under that particular simulated districting map.

I also performed the same calculations for the enacted 2017 House Plan and the enacted 2017 Senate Plan. In other words, I aggregated the block-level results from the 2010-2016 statewide elections to the level of the 2017 House and Senate districts and determined how many districts Republicans and Democrats were expected to win under the enacted plans, based on these past statewide election results. As a statistical matter, if an enacted plan had been drawn without partisanship as its predominant consideration, the enacted plan's partisan breakdown of seats would fall somewhere roughly within the normal range of the distribution of simulated, non-partisan plans. If the enacted plan is in the far tail end of the distribution, or lies outside the distribution altogether—meaning that it favors a particular party more than in the vast majority

or all of the simulated plans—then such a finding is a strong indication that the enacted plan was drawn with an overriding partisan intent to favor that political party, rather than to follow non-partisan, traditional districting criteria.

By randomly drawing districting plans with a process designed to strictly follow non-partisan districting criteria, the computer simulation process thus gives us a precise indication of the range of districting plans that plausibly and likely emerge when map-drawers are not motivated primarily by partisan goals. By comparing the enacted plans against the range of simulated plans with respect to partisan measurements, I am able to determine the extent to which a map-drawer's subordination of non-partisan districting criteria, such as geographic compactness and following municipal and precinct boundaries, was motivated by partisan goals.

These computer simulation methods are widely used by academic scholars to analyze districting maps. For over a decade, political scientists have used such computer-simulated districting techniques to make inferences about the racial and partisan intent of legislative map-drawers.² In recent years, a number of courts have also relied upon computer simulations to assess partisan bias in enacted districting plans.³

Non-Partisan Districting Criteria for North Carolina's Legislative Districts

In programming the computer simulation algorithm to produce House and Senate districting plans for North Carolina, I strictly followed the non-partisan portions of the 2017 Adopted Criteria, as adopted by the General Assembly's Joint Select Committee on Redistricting on August 10, 2017. Below, I describe these seven non-partisan districting criteria in detail and explain how each criterion is implemented by the computer algorithm to produce simulated plans for North Carolina's House and Senate districts:

1) *Population Equality*: The Adopted Criteria require legislative districts to contain populations within a 5% deviation of the ideal district population, as calculated using 2010 federal decennial census data. North Carolina's 2010 Census population was 9,535,483, so

² E.g., Carmen Cirincione, Thomas A. Darling, Timothy G. O'Rourke. "Assessing South Carolina's 1990s Congressional Districting," *Political Geography* 19 (2000) 189–211; Jowei Chen, "The Impact of Political Geography on Wisconsin Redistricting: An Analysis of Wisconsin's Act 43 Assembly Districting Plan." *Election Law Journal*

³ See, e.g., *League of Women Voters of Pa. v. Commonwealth*, 178 A. 3d 737, 818-21 (Pa. 2018); *Raleigh Wake Citizens Association v. Wake County Board of Elections*, 827 F.3d 333, 344-45 (4th Cir. 2016); *City of Greensboro v. Guilford County Board of Elections*, No. 1:15-CV-599, 2017 WL 1229736 (M.D.N.C. Apr 3, 2017); *Common Cause v. Robert A. Rucho*, No. 1:16-CV-1164 (M.D.N.C. Jan 11, 2018).

districts in the 120-member House have an ideal district population of 79,462, with an permissible range of 75,489 (95% of the ideal population) to 83,435 (105% of the ideal population). Each of the 50 Senate districts has an ideal district population of 190,710, with an permissible range of 181,174 (95% of the ideal population) to 200,245 (105% of the ideal population).

2) Contiguity: The computer simulation algorithm requires districts to be geographically contiguous, with contiguity by water permitted.

3) County Groupings: The 2017 Adopted Criteria requires that all House and Senate districts remain fully within a single county grouping. In applying this requirement, the computer simulation algorithm uses exactly the same county groupings as are used by the 2017 House Plan and the 2017 Senate Plan, producing districts that each lie fully within one of the existing county groupings. Because the computer follows the same county groupings as the enacted plans, the simulated plans essentially freeze those enacted House and Senate districts located in county groupings that contain only a single district, as there are no alternative ways to draw those districts within the contours of the existing county groupings. Within each county grouping, the number of districts in each simulated plan (including both frozen districts and computer-simulated districts) is identical to the number of districts in the enacted 2017 House Plan and the 2017 Senate Plan.

Specifically, the enacted 2017 House Plan divides North Carolina's 100 counties into 41 county groupings. These 41 county groupings are listed and described in detail in Table 1. Thirteen of the county groupings in the House Plan contain only a single district, while the remaining 28 groupings contain two or more districts. In the 13 county groupings that contain only a single House district, the computer simulation algorithm simply freezes the single district contained within each of these groupings, since there are no alternative ways to draw these districts (because the district merely comprises one or more whole counties). These frozen districts are listed in the final column in Table 1. Thus, the simulation algorithm does not create any additional district lines or districts within these single-district county groupings. The final column of Table 1 also lists the number of computer-simulated districts within each of the House county groupings.

Meanwhile, the Senate Plan contains 29 county groupings, and 17 of these county groupings contain only a single district, while the remaining 12 groupings contain two or more

districts. In the 17 county groupings that contain only a single Senate district, the computer simulation algorithm simply freezes the single district contained within each grouping; these frozen districts are listed in the final column in Table 2. The final column of Table 2 also lists the number of computer-simulated districts within each of the Senate county groupings.

4) *Minimizing County Traversals:* The 2017 Adopted Criteria requires the minimization of county traversals by legislative districts. In order to comply with this criterion, I counted the total number of county traversals in each plan by counting, for each district, the number of county borders that must be crossed to traverse all parts of the district. If a district includes two, non-contiguous portions of a single county, then such a scenario would involve two county traversals. As an example, consider the Cabarrus-Davie-Montgomery-Richmond-Rowan-Stanly County grouping in the House. The 2017 House Plan creates five total county traversals in this county grouping: one in HD-77 (from Davie to Rowan County), one in HD-83 (from Rowan to Cabarrus County), one in HD-67 (from Cabarrus to Stanly County), and two in HD-66 (from Stanly to Montgomery County and then from Montgomery to Richmond County).

To comply with the county traversal requirement, the simulation algorithm guarantees that each county grouping contains only the minimum possible number of county traversals. As a result, each computer-simulated House plan contains exactly as many county traversals as the 2017 House Plan, while each computer-simulated Senate plan contains exactly as many county traversals as the 2017 Senate Plan. Within each county grouping, the simulation algorithm allows districts to cross county boundaries only when necessary to equalize district populations, with no double traversals permitted, and this restriction effectively minimizes the number of county traversals.

Additionally, minimizing county traversals in every single simulated House and Senate plan also resulted in plans that contain exactly the same number of split counties as the 2017 House Plan and 2017 Senate Plan. After producing the simulated plans in House Simulation Set 1 and 2 and Senate Simulation Sets 1 and 2, I re-analyzed these 4,000 computer-simulated plans to verify that each one contains exactly the same number of split counties and county traversals as the 2017 House Plan and the 2017 Senate Plan.

Table 1: County Groupings Used for the 2017 House Plan and All Computer-Simulated House Plans

County Grouping:	Counties Included:	2017 House Plan Districts:	Number of Computer-Simulated Districts in Grouping:
1	(1) Alamance	HD-63; HD-64	2
2	(6) Alexander; Alleghany; Rockingham; Stokes; Surry; Wilkes	HD-65; HD-90; HD-91; HD-94	4
3	(2) Anson; Union	HD-55; HD-68; HD-69	3
4	(2) Ashe; Watauga	HD-93	none (HD-93 is frozen)
5	(3) Avery; McDowell; Mitchell	HD-85	none (HD-85 is frozen)
6	(2) Beaufort; Craven	HD-3; HD-79	2
7	(6) Bertie; Camden; Chowan; Perquimans; Tyrrell; Washington	HD-1	none (HD-1 is frozen)
8	(7) Bladen; Greene; Harnett; Johnston; Lee; Sampson; Wayne	HD-10; HD-21; HD-22; HD-26; HD-28; HD-51; HD-53	5 (Additionally, Special Master Districts HD-21 and HD-22 are frozen)
9	(2) Brunswick; New Hanover	HD-17; HD-18; HD-19; HD-20	4
10	(1) Buncombe	HD-114; HD-115; HD-116	3
11	(2) Burke; Rutherford	HD-86; HD-112	2
12	(6) Cabarrus; Davie; Montgomery; Richmond; Rowan; Stanly	HD-66; HD-67; HD-76; HD-77; HD-82; HD-83	6
13	(1) Caldwell	HD-87	none (HD-87 is frozen)
14	(2) Carteret; Jones	HD-13	none (HD-13 is frozen)
15	(2) Caswell; Orange	HD-50; HD-56	2
16	(1) Catawba	HD-89; HD-96	2
17	(2) Chatham; Durham	HD-29; HD-30; HD-31; HD-54	4
18	(4) Cherokee; Clay; Graham; Macon	HD-120	none (HD-120 is frozen)
19	(2) Cleveland; Gaston	HD-108; HD-109; HD-110; HD-111	4
20	(3) Columbus; Pender; Robeson	HD-16; HD-46; HD-47	3
21	(1) Cumberland	HD-42; HD-43; HD-44; HD-45	4
22	(4) Currituck; Dare; Hyde; Pamlico	HD-6	none (HD-6 is frozen)
23	(1) Davidson	HD-80; HD-81	2
24	(2) Duplin; Onslow	HD-4; HD-14; HD-15	3
25	(2) Edgecombe; Martin	HD-23	none (HD-23 is frozen)
26	(2) Forsyth; Yadkin	HD-71; HD-72; HD-73; HD-74; HD-75	5
27	(2) Franklin; Nash	HD-7; HD-25	2
28	(3) Gates; Hertford; Pasquotank	HD-5	none (HD-5 is frozen)
29	(4) Granville; Person; Vance; Warren	HD-2; HD-32	2

30	(1) Guilford	HD-57; HD-58; HD-59; HD-60; HD-61; HD-62	3 (Additionally, Special Master Districts HD-57, HD-61, and HD-62 are frozen)
31	(2) Halifax; Northampton	HD-27	none (HD-27 is frozen)
32	(5) Haywood; Jackson; Madison; Swain; Yancey	HD-118; HD-119	2
33	(3) Henderson; Polk; Transylvania	HD-113; HD-117	2
34	(2) Hoke; Scotland	HD-48	none (HD-48 is frozen)
35	(1) Iredell	HD-84; HD-95	2
36	(2) Lenoir; Pitt	HD-8; HD-9; HD-12	3
37	(1) Lincoln	HD-97	none (HD-97 is frozen)
38	(1) Mecklenburg	HD-88; HD-92; HD-98; HD-99; HD-100; HD-101; HD-102; HD-103; HD-104; HD-105; HD-106; HD-107	12
39	(2) Moore; Randolph	HD-52; HD-70; HD-78	3
40	(1) Wake	HD-11; HD-33; HD-34; HD-35; HD-36; HD-37; HD-38; HD-39; HD-40; HD-41; HD-49	11
41	(1) Wilson	HD-24	none (HD-24 is frozen)

Note: In the final column of this table, House districts from the 2017 House Plan that are 'frozen' are automatically drawn in every computer-simulated House plan, without any altering or redrawing by the simulation algorithm. Frozen districts include: 1) House districts materially redrawn in 2017 by the Special Master; and 2) 2017 House Plan districts in county groupings that contain only a single district.

Table 2: County Groupings Used for the 2017 Senate Plan and All Computer-Simulated Senate Plans

County Grouping:	Counties Included:	2017 Senate Plan Districts:	Number of Computer-Simulated Districts in Grouping:
1	(3) Alamance; Guilford; Randolph	SD-24; SD-26; SD-27; SD-28	2 (Special Master Districts SD-24 and SD-28 are frozen)
2	(2) Alexander; Catawba	SD-42	none (SD-42 is frozen)
3	(8) Alleghany; Ashe; Caswell; Rockingham; Stokes; Surry; Watauga; Wilkes	SD-30; SD-45	2
4	(4) Anson; Moore; Richmond; Scotland	SD-25	none (SD-25 is frozen)
5	(3) Avery; Burke; Caldwell	SD-46	none (SD-46 is frozen)
6	(6) Beaufort; Bertie; Martin; Northampton; Vance; Warren	SD-3	none (SD-3 is frozen)
7	(4) Bladen; Brunswick; New Hanover; Pender	SD-8; SD-9	2
8	(3) Buncombe; Henderson; Transylvania	SD-48; SD-49	2
9	(2) Cabarrus; Union	SD-35; SD-36	2
10	(11) Camden; Chowan; Currituck; Dare; Gates; Hertford; Hyde; Pasquotank; Perquimans; Tyrrell; Washington	SD-1	none (SD-1 is frozen)
11	(3) Carteret; Craven; Pamlico	SD-2	none (SD-2 is frozen)
12	(2) Chatham; Orange	SD-23	none (SD-23 is frozen)
13	(7) Cherokee; Clay; Graham; Haywood; Jackson; Macon; Swain	SD-50	none (SD-50 is frozen)
14	(3) Cleveland; Gaston; Lincoln	SD-43; SD-44	2
15	(2) Columbus; Robeson	SD-13	none (SD-13 is frozen)
16	(2) Cumberland; Hoke	SD-19; SD-21	none (Special Master Districts SD-19 and SD-21 are frozen)
17	(2) Davidson; Montgomery	SD-29	none (SD-29 is frozen)
18	(2) Davie; Forsyth	SD-31; SD-32	2
19	(6) Duplin; Harnett; Johnston; Lee; Nash; Sampson	SD-10; SD-11; SD-12	3
20	(3) Durham; Granville; Person	SD-20; SD-22	2
21	(3) Edgecombe; Halifax; Wilson	SD-4	none (SD-4 is frozen)
22	(2) Franklin; Wake	SD-14; SD-15; SD-16; SD-17; SD-18	5
23	(2) Greene; Pitt	SD-5	none (SD-5 is frozen)
24	(2) Iredell; Yadkin	SD-34	none (SD-34 is frozen)
25	(2) Jones; Onslow	SD-6	none (SD-6 is frozen)
26	(2) Lenoir; Wayne	SD-7	none (SD-7 is frozen)
27	(6) McDowell; Madison; Mitchell; Polk; Rutherford; Yancey	SD-47	none (SD-47 is frozen)
28	(1) Mecklenburg	SD-37; SD-38; SD-39; SD-40; SD-41	5
29	(2) Rowan; Stanly	SD-33	none (SD-33 is frozen)

Note: Senate districts that are 'frozen' are automatically drawn in every computer-simulated Senate plan.

5) Geographic Compactness: The 2017 Adopted Criteria mandates the consideration of geographic compactness in the drawing of legislative districts, specifying two commonly-used measures of district compactness: The Reock score and the Polsby-Popper score.

The computer simulation algorithm thus attempts to draw geographically compact districts whenever doing so does not violate any of the aforementioned criteria. After completing the computer simulations, I then compare the compactness of the simulated plans and the enacted plans using the two measures of compactness specified by the 2017 Adopted Criteria:

First, I calculate the average Reock score of the districts within each plan. The Reock score for each individual district is calculated as the ratio of the district's area to the area of the smallest bounding circle that can be drawn to completely contain the district; thus, higher Reock score indicate more geographically compact districts. The 2017 House Plan has an average Reock score of 0.4124 across its 120 districts, while the 2017 Senate Plan has an average Reock score of 0.4267 across its 50 districts. As detailed later in this report, every one of the 2,000 computer-simulated House plans in House Simulation Sets 1 and 2 is significantly more compact than the 2017 House Plan, as measured by average Reock score. Similarly, every one of the 2,000 simulated Senate plans in Senate Simulation Sets 1 and 2 is significantly more compact than the 2017 Senate Plan, as measured by average Reock score.

Second, I calculate the average Polsby-Popper score of each plan's districts. The Polsby-Popper score for each individual district is calculated as the ratio of the district's area to the area of a hypothetical circle whose circumference is identical to the length of the district's perimeter; thus, higher Polsby-Popper scores indicate greater district compactness. The 2017 House Plan has an average Polsby-Popper score of 0.3206 across its 120 districts, while the 2017 Senate Plan has an average Polsby-Popper score of 0.3480 across its 50 districts. As described later, every single one of the 2,000 computer-simulated House plans in this report has a higher Polsby-Popper score than the 2017 House Plan, and every single one of the 2,000 simulated Senate plans has a higher Polsby-Popper score than the 2017 Senate Plan.

6) Minimizing Split Precincts: North Carolina is divided into 2,692 Voting Tabulation Districts ("VTDs"), which is the generic term used by the US Census Bureau to describe North Carolina's precincts in maps depicting census geographies. Although the 2017 Adopted Criteria uses the term "precincts," the General Assembly's Reference Data used during the 2017 redistricting process use the term "VTD." Additionally, the General Assembly's Stat Pack

documents analyzing its House and Senate plans during the 2017 redistricting process also use the term "Split VTDs."⁴ I therefore follow the General Assembly's practice by using Census VTD boundaries in analyzing each simulated plan and the enacted plans.

Avoiding the splitting of precincts is a traditional districting criterion as well as a consideration mandated by the 2017 Adopted Criteria. The computer simulation algorithm thus attempts to keep VTDs intact and not split them into multiple districts. In calculating the number of split municipalities in each districting plan, I rely upon the VTD boundary maps included in the geographic Reference Data used and made available by the General Assembly in its various rounds of redistricting during the current decade.⁵ I use these VTD boundary maps, rather than any of the precinct maps compiled and produced by the State Board of Elections, because the General Assembly produced and used these data during its own redistricting. I count a VTD as split only if a populated portion of a VTD is assigned to a different district than the remainder of the VTD. Hence, I do not count a VTD as split if only an unpopulated portion of a VTD is assigned to a different district than the remainder of the VTD.

Overall, the 2017 House Plan splits 48 VTDs, while the 2017 Senate Plan splits 5 VTDs. As described later in this report, all 2,000 of the computer simulated House maps and all 2,000 of the simulated Senate maps produced in this report split fewer VTDs than the 2017 House Plan and the 2017 Senate Plan, respectively. The computer-simulated House plans split from 6 to 20 VTDs in each plan, while the computer-simulated Senate plans split from 0 to 3 VTDs in each plan.

7) Following Municipal Boundaries: A traditional districting principle in the drawing of districting plans is the avoidance of splitting municipalities. Following municipal boundaries is also explicitly mentioned as a consideration in the 2017 Adopted Criteria. North Carolina contains 553 incorporated municipalities, including both cities and townships. The computer simulation algorithm attempts to keep these municipalities intact and not split them into multiple districts.

⁴ The House plan Stat Pack was downloaded from:
https://www.ncleg.net/Sessions/2017/h927maps/H927%20Plan%20A2%20HBK-25%20-%20dc2016GE_StatPack.pdf

The Senate plan Stat Pack was downloaded from:
<https://www.ncleg.gov/Sessions/2017/s691maps/S691%204th%20Ed.Combined.pdf>

⁵ Downloaded from: <https://www.ncleg.gov/RnR/Redistricting/BaseData2011>.

For the purpose of counting municipal splits, I treat a municipality that is divided across two counties as two separate municipalities. Hence, a municipality that partially lies within two counties, each of which is assigned to a separate district, does not count as a split municipality. Additionally, a municipality that primarily lies within one district but has an unpopulated area assigned to a different district is not counted as a split municipality.

Overall, the 2017 House Plan splits 79 municipalities, while the 2017 Senate Plan splits 25 municipalities. As described later in this report, all 2,000 of the computer-simulated House maps and the 2,000 of the simulated Senate maps produced in this report split far fewer municipalities than the 2017 House Plan and the 2017 Senate Plan, respectively.

Freezing Districts Drawn by the Special Master: In the *Covington* litigation, Special Master Nathaniel Persily redrew two House districts (HD-21 and HD-57) and two Senate districts (SD-21 and SD-28) that the federal court had found to be racially gerrymandered. In redrawing those districts, to equalize population, the Special Master also made material changes to HD-22, HD-61, and HD-62 in the House, and SD-19, SD-24, and SD-27 in the Senate. With one exception described below, I freeze these Special Master-drawn districts in all computer-simulated House and Senate plans produced for this report.

In every computer-simulated House plan in House Simulation Set 1 and Set 2, I freeze all five of the above-listed Special Master-drawn House districts. These frozen districts are HD-21, HD-22, HD-57, HD-61, and HD-62, and they appear in every House simulated plan exactly as drawn in the enacted 2017 House Plan.

In every computer-simulated Senate plan in Senate Simulation Set 1 and Set 2, I freeze four of the five Special Master-drawn Senate districts. These four frozen Senate districts are SD-19, SD-21, SD-24, and SD-28, and they appear in every Senate simulated plan exactly as drawn in the enacted 2017 Senate Plan. The fifth Senate district drawn by the Special Master, SD-27 (Guilford County), is not frozen in any of the simulated plans. Freezing SD-27 along with SD-24 and SD-28, combined with the existing boundaries of the Alamance-Guilford-Randolph county grouping, would effectively also freeze the boundaries of the remaining district in this county grouping, SD-26, which the Special Master did not alter at all in 2017. Instead of freezing SD-27, the computer algorithm produces two computer-simulated Senate districts in the area currently occupied by SD-26 and SD-27 in the 2017 Senate Plan, following the non-partisan redistricting criteria outlined above. Because my algorithm freezes SD-24 and SD-28 from the

2017 Senate Plan, the only portions of this county grouping that my simulations change from the 2017 Senate Plan are the district borders between SD-26 and SD-27 in southern Guilford County. To be clear, the simulations make no changes to SD-28, which is the actual district that the Special Master was tasked with redrawing because it had been previously found racially gerrymandered.

No Consideration of Partisan or Racial Data: The simulation algorithm makes no use of any racial data, and no such data is made available to the algorithm. Additionally, no political or partisan data is used by the simulation algorithm, aside from the consideration of incumbent legislators' home addresses in House Simulation Set 2 and Senate Simulation Set 2, as described later in this report.

Uniqueness of Each Computer-Simulated Districting Plan: Because the simulation algorithm randomly draws district borders, each statewide House or Senate plan produced by the algorithm is different. After the algorithm created 4,000 districting plans (in House Simulation Sets 1 and 2 and Senate Simulation Sets 1 and 2), I examined each of these 4,000 statewide plans and verified that no two computer-simulated plans are identical to one another.

Measuring the Partisanship of Districting Plans

I use actual election results from recent, statewide election races in North Carolina to assess the partisan performance of the simulated and enacted districting plans analyzed in this report. Overlaying these past election results onto a districting plan enables me to calculate the number of Republican- and Democratic-leaning districts within each simulated plan and within the 2017 House and 2017 Senate Plans. These calculations thus allow me to directly compare the partisanship of the enacted plan and the simulated plans. These partisan comparisons allow me to determine whether or not the partisan distribution of seats in the enacted plan could reasonably have arisen from a districting process respecting the non-partisan traditional districting criteria. Past voting history in federal and statewide elections is a strong predictor of future voting history. Mapmakers thus can and do use past voting history to identify the class of voters, at a precinct-by-precinct level, who are likely to vote for Democratic (or Republican) candidates for the state legislature.

In general, the most reliable method of comparing the partisanship of different legislative districts within a state is to consider whether these districts have tended to favor Republican or

Democratic candidates in recent, competitive *statewide* elections, such as the Presidential, Gubernatorial, Attorney General, and US Senate elections. Recent statewide elections provide the most reliable bases for comparisons of different precincts' partisan tendencies because in any statewide election, the anomalous candidate-specific effects that shape the election outcome are equally present in all precincts across the state. Statewide elections are thus a better basis for comparison than the results of legislative elections because the particular outcome of any legislative election may deviate from the long-term partisan voting trends of that precinct, due to factors idiosyncratic to the legislative district as currently constructed. Such factors can include the presence or absence of a quality challenger, anomalous difference between the candidates in campaign efforts or campaign finances, incumbency advantage, candidate scandals, and coattail effects.⁶ Because these idiosyncratic factors would change if the legislative district were drawn differently, it is particularly unsuitable to use election results from an existing legislative district when comparing the partisanship of an existing district to a simulated district that would have different boundaries.

Indeed, in both the 2011 and 2017 rounds of redistricting the North Carolina House and Senate, the General Assembly publicly disclosed that it was relying solely on recent statewide elections in measuring the partisanship of the state legislative districts being created.

The 2010-2016 Statewide Election Results: The 2017 Adopted Criteria describe the use of "elections results data" during the drawing of the 2017 House and Senate plans. Furthermore, during the August 10, 2017 meeting of the Joint Select Committee on Redistricting, Representative David Lewis specified the ten past statewide elections whose results would be considered by the Committee in drawing the 2017 legislative plan districts. These ten statewide elections contests are: The 2010 US Senate election, the 2012 US President, Governor, and Lieutenant Governor elections, the 2014 US Senate election, and the 2016 US President, US Senate, Governor, Lieutenant Governor, and Attorney General elections.

In this report, I primarily use this same set of ten election results to measure the partisan performance of the enacted and computer-simulated districting plans I analyze. These election results enable me to calculate the number of Republican- and Democratic-leaning districts within each plan, thus allowing me to determine whether or not the partisan distribution of seats in the

⁶ E.g., Alan Abramowitz, Brad Alexander, and Matthew Gunning. "Incumbency, Redistricting, and the Decline of Competition in U.S. House Elections." *The Journal of Politics*. Vol. 68, No. 1 (February 2006): 75-88.

enacted plan could reasonably have arisen from a districting process respecting the various traditional criteria set forth in the Adopted Criteria.

Specifically, I evaluate the partisanship of legislative districts in North Carolina by counting up the total number of Republican and Democratic votes cast in these ten statewide elections. I weigh each election equally and calculate, within each district, the Democratic and Republican share of the two-party votes (i.e., votes for the Democratic and Republican candidates) aggregated across all ten of these elections. I also count whether each district contains more Republican or Democratic voters, aggregated over all of these ten elections. I find that, using the results of these ten elections, total Republican votes outnumbered total Democratic votes in 78 districts in the 2017 House Plan and in 32 districts in the 2017 Senate Plan. Throughout this report, except where otherwise noted, I apply this same formula for evaluating all of the simulated districting plans, allowing for a direct comparison of the partisanship of the enacted and the simulated plans. I refer to the aggregated election results from these ten statewide elections as the "2010-2016 Statewide Election Composite."

Table 3 illustrates an example of how the 2010-2016 Statewide Election Composite is used to measure the partisanship of individual districts throughout this report. This Table reports the number of votes for the Democratic and Republican candidates in each of the ten statewide elections for HD-1 and HD-5 in the 2017 House Plan. Tallying the results of the ten statewide elections in HD-1, Democrats received a total of 164,682 votes, while Republicans received 165,368 total votes. Thus, Democrats' share of the two-party vote in HD-1 across these ten elections was 49.90%, and I therefore classify this district as a Republican-favoring district using the 2010-2016 Statewide Election Composite. On the other hand, voters in HD-5 cast a total of 174,448 Democratic votes and 122,275 Republican votes across the ten elections, giving Democrats a two-party vote share of 58.79%. I therefore classify HD-5 as a Democratic-favoring district using the 2010-2016 Statewide Election Composite. Throughout this report, except where otherwise noted, I measure the partisanship of every district using the 2010-2016 Statewide Election Composite when producing statewide comparisons of the computer-simulated plans and to the 2017 House and Senate Plans.

The 2004-2010 Statewide Election Results: The 2017 House Plan and the 2017 Senate Plan both include some districts that remained unchanged from the General Assembly's previous legislative districting plans enacted in 2011. Specifically, 41 districts in the 2017 House Plan and

15 districts in the 2017 Senate Plan were left unaltered from the previous districting plans enacted in 2011. Because the General Assembly originally drew these districts in 2011, in order to assess the General Assembly’s intent at the time of drawing these districts, I use the pre-2011 election data available to and used by the General Assembly when I evaluate the county groupings containing these districts that were drawn in 2011 and not altered in 2017.

**Table 3:
The Calculation of District-Level Partisanship Using the 2010-2016 Statewide Election Composite:**

Election Contest:	House District 1 (2017 House Plan):		House District 5 (2017 House Plan):	
	Democratic Votes	Republican Votes	Democratic Votes	Republican Votes
2010 US Senate	11,572	12,798	10,791	8,307
2012 US President	19,188	17,761	20,871	13,179
2012 Governor	19,104	16,908	20,700	12,290
2012 Lieutenant Governor	20,570	15,314	21,685	11,591
2014 US Senate	12,208	11,858	11,521	7,987
2016 US President	16,455	18,589	17,840	14,071
2016 US Senate	16,040	18,358	17,542	13,942
2016 Governor	16,170	18,855	17,723	14,115
2016 Lieutenant Governor	16,328	17,778	17,580	13,598
2016 Attorney General	17,047	17,149	18,195	13,195
Total Votes:	164,682	165,368	174,448	122,275
Democratic Vote Share, measured using 2010-2016 Statewide Election Composite:	49.90%		58.79%	

Specifically, during the 2011 redistricting cycle, the General Assembly's "2011 Redistricting Database" contained the results from 15 statewide elections held during 2004-2010. These 15 statewide elections contests are: The 2004 US President, US Senate, Governor, and Auditor elections, the 2008 US President, US Senator, Governor, Lieutenant Governor, Attorney General, Auditor, Commissioner of Agriculture, Commissioner of Insurance, Commissioner of Labor, and Superintendent of Public Instruction elections, and the 2010 US Senate election. Thus, when analyzing specific county groupings from the 2017 House and 2017 Senate Plans

containing 2011-drawn districts, I measure the partisanship of these 2011-drawn districts by counting up the total number of Republican and Democratic votes cast within these districts in these 15 pre-2011 statewide elections. As before, I weigh each election equally and calculate, within each district, the Democratic and Republican share of the two-party votes aggregated across all 15 of these elections. This aggregated set of 15 pre-2011 election results was the data available to the General Assembly when it enacted the 2011-drawn districts, and this pre-2011 partisanship measure is hereinafter referred to as the "2004-2010 Statewide Election Composite."

Table 4 illustrates an example of how the 2004-2010 Statewide Election Composite is used to measure the partisanship of the 2011-drawn districts that remained unchanged in the 2017 House and 2017 Senate Plans. The General Assembly originally drew the boundaries of HD-63 and HD-64 in Alamance County in the 2011 House Plan, and the boundaries of these two districts remained unchanged in the 2017 House Plan. Therefore, when I evaluate the partisanship of House districts in the Alamance County grouping, I use the 2004-2010 Statewide Election Composite. Table 4 reports the number of votes for the Democratic and Republican candidates in each of the 15 statewide elections for HD-63 and HD-64. Tallying the results of these 15 statewide elections in HD-63, Democrats received a total of 191,146 votes, while Republicans received 202,805 total votes. Thus, Democrats' share of the two-party vote in HD-63 across these 15 elections was 48.52%, and I therefore describe this district as having a 48.52% Democratic vote share using the 2004-2010 Statewide Election Composite in my county grouping-by-grouping analysis later in this report. Similarly, HD-64 cast a total of 166,385 Democratic votes and 190,719 Republican votes across these 15 elections, giving Democrats a two-party vote share of 46.59%, using the 2004-2010 Statewide Election Composite.

Note that throughout this report, I use the 2004-2010 Statewide Election Composite only in my county grouping-level analysis of specific groupings containing districts that were originally drawn in 2011. This county grouping-by-grouping analysis is illustrated in Figures 25 to 94 and is described in detail later in this report. I do not use the 2004-2010 Statewide Election Composite in any of my statewide comparisons of the computer-simulated plans and the 2017 enacted plans (which appear in Tables 5 and 6 and Figures 1 to 24 and is described in detail later in this report). For all statewide comparisons of simulated and enacted districting plans, I use 2010-2016 statewide elections to measure the partisanship of each plan.

Table 4:
Calculating the Partisanship of Districts Originally Drawn in 2011
Using the 2004-2010 Statewide Election Composite:

Election Contest:	House District 63 (2017 House Plan):		House District 64 (2017 House Plan):	
	Democratic Votes	Republican Votes	Democratic Votes	Republican Votes
2004 Auditor	6,917	8,204	6,496	8,089
2004 Governor	8,598	7,320	7,986	7,314
2004 US President	6,390	9,805	5,934	9,563
2004 US Senate	7,048	8,891	6,512	8,774
2008 Attorney General	19,822	13,147	16,803	12,668
2008 Auditor	16,380	15,702	14,036	14,637
2008 Commissioner of Agriculture	13,804	18,814	11,569	17,726
2008 Commissioner of Insurance	15,721	15,394	13,356	14,456
2008 Commissioner of Labor	14,245	18,164	12,284	16,671
2008 Governor	16,195	16,257	14,261	14,824
2008 Lieutenant Governor	15,600	16,241	13,454	15,095
2008 US President	15,506	18,093	13,412	16,766
2008 Superintendent of Public Instruction	9,856	7,744	8,799	7,509
2008 US Senate	16,582	15,998	14,519	14,646
2010 US Senate	8,482	13,031	6,964	11,981
Total Votes:	191,146	202,805	166,385	190,719
Democratic Vote Share, measured using 2004-2010 Statewide Election Composite:	48.52%		46.59%	

Statewide Measures of a Districting Plan's Partisan Bias: In this report, I present three different measures of the partisanship of each enacted and computer-simulated districting plan analyzed:

Number of Democratic and Republican Districts: First, using the 2010-2016 Statewide Election Composite, I count the number of Republican- and Democratic-leaning districts in each plan. A district is classified as Republican if the total sum of Republican votes in the district across all of the 2010-2016 elections (or, where relevant, the 2004-2010 elections) exceeds the total sum of Democratic votes; otherwise, the district is classified as Democratic. Under this measure, every district in a plan is classified as either Democratic or Republican, and I use this

measure to compare the partisanship of each enacted plan to the computer-simulated plans for each legislative chamber.

Uniform Swing Adjustments: Second, I apply a series of uniform swing adjustments to the 2010-2016 Statewide Election Composite, and I calculate the number of Democratic-favoring districts in each enacted plan and the computer-simulated plans under these different uniform swing adjustments. I apply various alternative uniform swings to the 2010-2016 Statewide Election Composite, ranging from -6% to +6% (at intervals of 0.5%). The use of uniform swing calculations is useful because it reveals and compares how the enacted plans and the computer-simulated plans would likely perform under varying electoral conditions (e.g., in a Republican-favorable election, a Democratic-favorable election, or a relatively even election).

Note that the 2010-2016 Statewide Election Composite produced an overall 47.92% Democratic vote share statewide. Therefore, a +0% uniform swing condition corresponds to a 47.92% statewide Democratic vote share, a +6% uniform swing corresponds to a 53.92% statewide Democratic vote share, and a -6% uniform swing corresponds to a 41.92% statewide Democratic vote share. Under each of these 25 uniform swing conditions (ranging from -6% to +6%), I calculate each computer-simulated plan's number of Democratic-favoring districts, as measured using the 2010-2016 Statewide Election Composite and adjusting for the uniform swing. I then compare these simulation calculations to the same calculations for the 2017 House Plan and the 2017 Senate Plan.

The Mean-Median Difference: Third, I calculate each districting plan's Mean-Median Difference, which is another accepted method that redistricting scholars commonly use for comparing the relative partisan bias of different districting plans. The Mean-Median Difference for any given plan is calculated as the mean district-level Democratic vote share, minus the median district-level Democratic vote share. For any House districting plan, the mean is simply calculated as the average of the Democratic vote shares in each of the 120 districts. For any House plan, the median is the Democratic vote share in the district where Democrats performed the middle-best, which is the district that Democrats would need to win to secure a majority of the chamber. Since a House plan contains 120 districts, all 120 districts are lined up in order from lowest to highest Democratic vote share, and the median district is calculated as the average of the Democratic vote share in the districts where Democrats performed the 60th and 61st-best across the state. Using the 2010-2016 Statewide Election Composite to measure partisanship, the

districts in the 2017 House Plan have a mean Democratic vote share of 47.84%, while the median district has a Democratic vote share of 42.50%. Thus, the 2017 House Plan has a Mean-Median Difference of +5.33%, indicating that the median district is skewed significantly more Republican than the plan's average district. This Mean-Median Difference suggests that, assuming uniform swings in the vote across the state, Democrats would need to win an average of 55.33% of the vote across all districts statewide in order to win the median district, and hence in order to win a majority of House seats in the General Assembly under the enacted 2017 House Plan. The Mean-Median Difference thus indicates that the enacted plan distributes voters across districts in such a way that most districts are significantly more Republican-leaning than the average North Carolina House district, while Democratic voters are more heavily concentrated in a minority of the 2017 enacted House districts. Similarly, in the enacted 2017 Senate Plan, I calculate a Mean-Median Difference of +3.4%. These skews in the enacted plans create a significant partisan advantage for Republicans by giving them stronger control over the median districts in each chamber. I perform the same calculation on all computer-simulated plans in order to determine whether this partisan skew in the median House and Senate districts could have resulted naturally from North Carolina's political geography and the application of partisan-neutral districting criteria.

House Simulation Set 1:

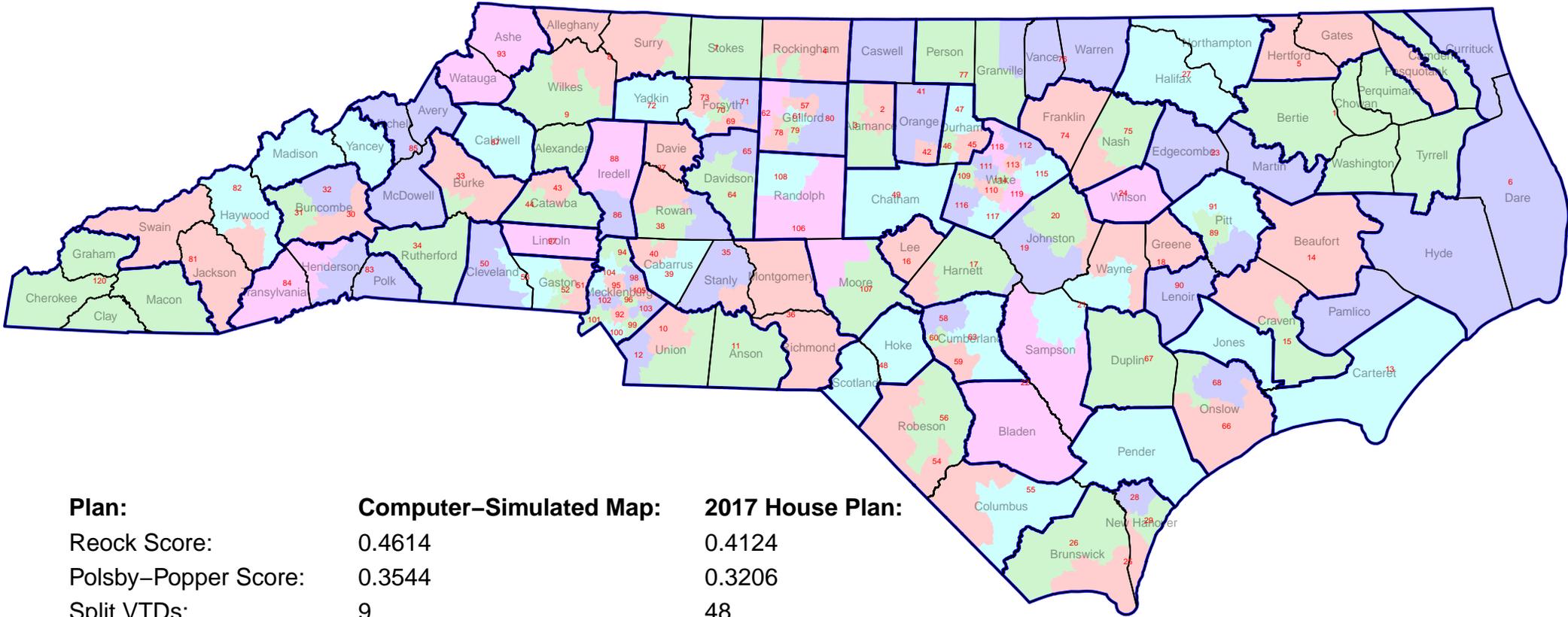
Following Traditional Districting Criteria with No Incumbent Protection

I conducted a first set of 1,000 computer simulations in which plans were drawn to optimize on the seven non-partisan, traditional districting criteria described previously: population equality, contiguity, following county groupings, avoiding county splits and traversals, geographic compactness, avoiding precinct splits, and avoiding municipal splits. Table 5 details how the 2017 House Plan compares to the simulated plans in House Simulation Set 1 and Set 2 with respect to these various districting criteria. (House Simulation Set 2 is discussed in further detail below). As an example of a computer-simulated map, Figure 1 illustrates the final of the 1,000 simulated districting plans produced by the computer algorithm in House Simulation Set 1.

Table 5: Summary of the Enacted 2017 House Plan and House Simulation Sets 1 and 2:

	2017 House Plan:	House Simulation Set 1:	House Simulation Set 2:
Description:	Current Enacted Plan	Simulated House maps following only non-partisan traditional districting criteria	Simulated House maps that: 1) Protect the maximum number of incumbents in each grouping; 2) Protect at least the same incumbents who were protected in the 2017 House Plan; and 3) Otherwise follow non-partisan traditional districting criteria.
Total Number of Simulated Plans:		1,000 simulated maps	1,000 simulated maps
Number of Split Municipalities*:	79	38 to 55	44 to 61
Number of Split VTDs*:	48	6 to 18	7 to 20
Average Reock Score (Compactness):	0.412	0.444 to 0.474	0.439 to 0.465
Average Polsby-Popper Score (Compactness):	0.321	0.348 to 0.384	0.336 to 0.371
Mean-Median Difference:	+0.053	+0.015 to +0.038	+0.012 to +0.040
Democratic Districts (using 2010-2016 Statewide Election Composite, which corresponds to a 47.92% statewide Democratic vote share):	42 (out of 120 districts)	43 (6 simulation) 44 (48 simulations) 45 (172 simulations) 46 (284 simulations) 47 (278 simulations) 48 (132 simulations) 49 (58 simulations) 50 (20 simulations) 51 (2 simulations)	43 (1 simulation) 44 (21 simulations) 45 (88 simulations) 46 (222 simulations) 47 (319 simulations) 48 (210 simulations) 49 (99 simulations) 50 (28 simulations) 51 (12 simulations)

**Figure 1:
Example of a Computer–Simulated House Map
From House Simulation Set 1 (Following Only Non–Partisan Redistricting Criteria)**



Plan:	Computer–Simulated Map:	2017 House Plan:
Reock Score:	0.4614	0.4124
Polsby–Popper Score:	0.3544	0.3206
Split VTDs:	9	48
Split Municipalities:	44	79
Mean–Median Difference:	+2.95%	+5.33%
Democratic Districts:	46	42

(District partisanship is measured using the 2010–2016 Statewide Election Composite, which produces a 47.92% statewide Democratic vote share.)

Legend:

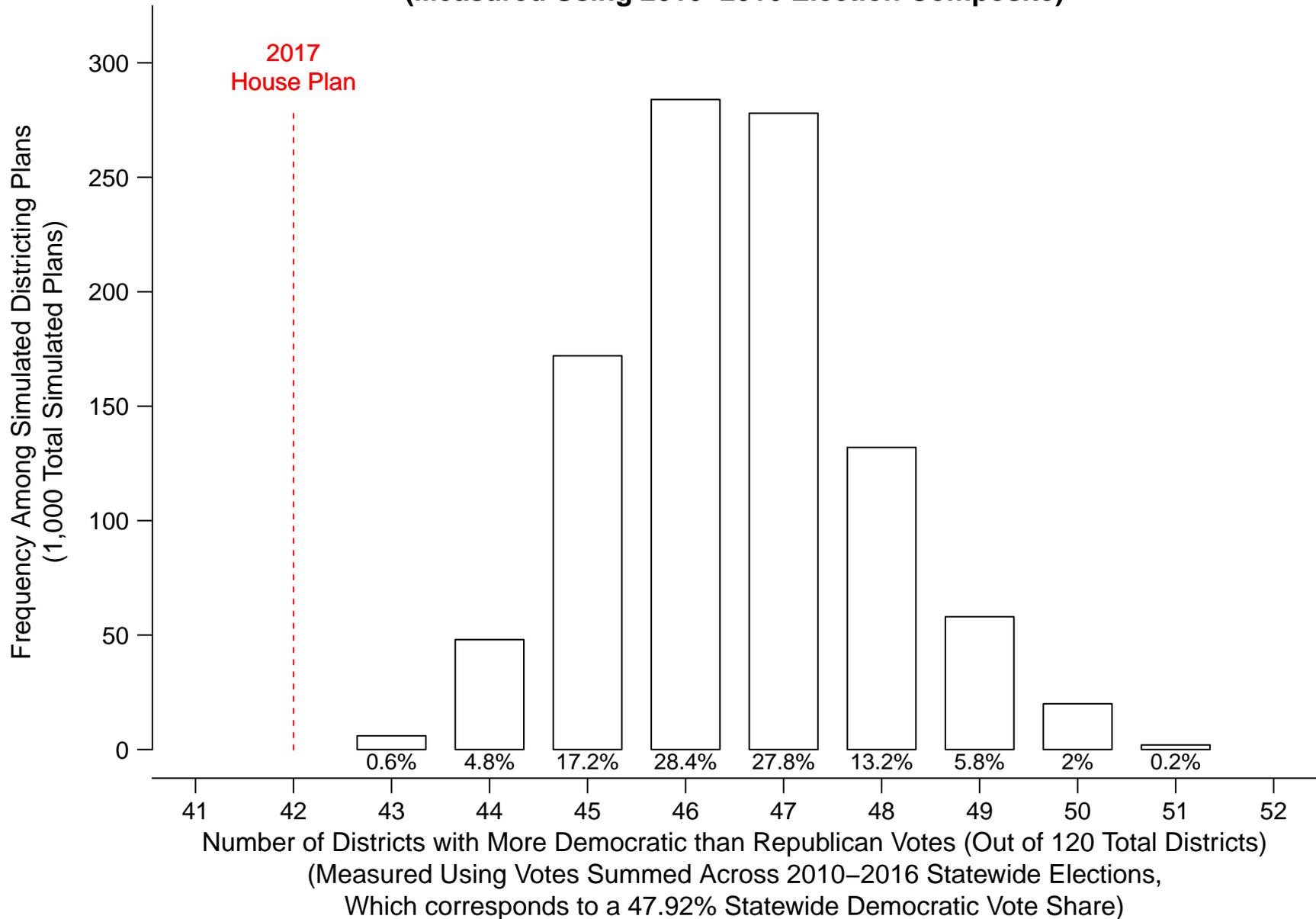
- County Grouping Boundaries
- County Boundaries
- Computer–Simulated House Districts (Including frozen districts from the 2017 House Plan) Numbered from 1 to 120

Number of Democratic and Republican Districts: Figure 2 compares the partisan breakdown of the simulated plans to the partisanship of the 2017 House Plan. Specifically, Figure 2 uses the 2010-2016 Statewide Election Composite to measure the number of Democratic-leaning districts created in each of the 1,000 simulated plans. As measured by these election results, which produce to a 47.92% statewide Democratic vote share, the vast majority of the simulated plans create from 45 to 48 Democratic districts out of 120 total districts using the ten statewide elections in the 2010-2016 Statewide Election Composite.

Using the 2010-2016 Statewide Election Composite, the most common outcome among the simulations is a plan containing 46 or 47 Democratic districts. In contrast, the projected number of Democratic districts under the enacted 2017 House plan is 42 seats using the 2010-2016 Statewide Election Composite, which is 4 to 5 fewer Democratic seats than under most of the computer-simulated plans. The 1,000 simulations do not produce a single plan that results in only 42 Democratic districts, the outcome observed in the 2017 House Plan. I thus conclude with extremely high statistical certainty that the enacted plan created a pro-Republican partisan outcome that would not have occurred under a districting process adhering to non-partisan traditional criteria.

Notably, the ten elections included in the 2010-2016 Statewide Election Composite generally occurred in election years and in electoral environments that were relatively favorable to Republicans across the country (in particular, 2010, 2014, and 2016). Hence, the projected number of Democratic seats would be even greater in the computer-simulated plans if one measured district partisanship using a statewide election whose outcome was more partisan-balanced or even favorable to Democrats. Indeed, in Appendix A, I present the projected number of Democratic seats across all of the House simulations using just the 2016 Attorney General election, which was a near-tied statewide election (Democrat Josh Stein and Republican Buck Newton each received approximately 50% of the two-party vote). Using the 2016 Attorney General election to measure district partisanship, the enacted 2017 House Plan contains 44 Democratic-favoring districts out of 120 total districts, while the computer-simulated plans most commonly contain 51 to 53 Democratic districts. Hence, using the 2016 Attorney General election results, the 2017 House Plan contains 7 to 9 fewer Democratic-leaning districts than most of the simulated plans.

**Figure 2:
House Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Democratic-Favoring Districts in 2017 House Plan Versus 1,000 Simulated Plans
(Measured Using 2010–2016 Election Composite)**



Uniform Swing Adjustments: Similarly, in Figures U1 to U3, I compare the partisanship of the 2017 House Plan and the 1,000 computer-simulated plans using various uniform swings. To create these Figures, I applied various alternative uniform swings to the 2010-2016 Statewide Election Composite, ranging from -6% to +6% (at intervals of 0.5%). Under each of these 25 uniform swing conditions, I calculate each House plan's number of Democratic-favoring House districts, as measured using the 2010-2016 Statewide Election Composite and adjusting for the uniform swing.

Figure U1 thus contains 25 rows, corresponding to these 25 different alternative uniform swings (e.g., +6%, +5.5%, +5.0%, etc.). As explained earlier, the 2010-2016 Statewide Election Composite produced an overall 47.92% Democratic vote share statewide. Therefore, a +0% uniform swing condition corresponds to a 47.92% statewide Democratic vote share, a +6% uniform swing corresponds to a 53.92% statewide Democratic vote share, and a -6% uniform swing corresponds to a 41.92% statewide Democratic vote share. The rows in Figure U1 are labeled with the statewide Democratic vote share that corresponds to the uniform swing applied in each row. The middle (13th from top) row in Figure U1 applies a +0% uniform swing, which corresponds to a 47.92% statewide Democratic vote share. Each row moving upward from this row depicts an additional +0.5% in the uniform swing applied, and each row moving downward depicts a decrease of 0.5% in the uniform swing applied. Therefore, the bottom row in figure U1 applies a -6% uniform swing, which corresponds to a 41.92% statewide Democratic vote share, and the top row applies a +6% uniform swing, which corresponds to a 53.92% statewide Democratic vote share.

I applied the uniform swings in each row as follows: A uniform swing adjustment of +4.5%, for example, means that I calculated each district's Democratic vote share using the 2010-2016 Statewide Election Composite and added +4.5% to each district's vote share. I made this same uniform swing adjustment for both the 2017 House Plan as well as for all 1,000 computer-simulated plans. I then identified the number of House districts in each plan with over a 50% Democratic vote share, after accounting for the uniform swing adjustment.

Figure U1 displays these calculations under each of the 25 different alternative uniform swings. The top row of Figure U1, which applies a uniform swing of +6% (corresponding to a 53.92% statewide Democratic vote share), reports the number of Democratic-favoring districts in each of the 1,000 simulated plans, as measured using the 2010-2016 Statewide Election

Composite with a +6% uniform swing. This row contains a series of numbers, corresponding to the horizontal axis, reporting the number of computer-simulated plans (out of 1,000) that contain a particular number of Democratic-favoring districts. Specifically, this top row reports 2 simulated plans containing 59 Democratic districts, 14 simulated plans containing 60 Democratic districts, 63 simulated plans containing 61 Democratic districts, and 207 simulated plans containing 62 Democratic districts, and so on. Hence, the numbers in Figure U1 report the number of simulated plans that would contain a particular number of Democratic districts, as listed along the horizontal axis of the Figure. The red star in each row of Figure U1 denotes the number of Democratic districts for the 2017 House Plan under each uniform swing adjustment.

Figure U1 reveals the uniform swing conditions under which the computer-simulated plans would create 60 or more Democratic-favoring districts. With a uniform swing of +5.0%, which corresponds to a 52.92% statewide Democratic vote share, 67.2% of the simulated plans in House Simulation Set 1 would create 60 or more Democratic-favoring districts. Meanwhile, under this same uniform swing condition, the 2017 House Plan would contain only 51 Democratic districts. Similarly, with a uniform swing of +4.5%, which corresponds to a 52.42% statewide Democratic vote share, 42.5% of the simulated plans in House Simulation Set 1 would create 60 or more Democratic-favoring districts, but the 2017 House Plan would contain only 48 Democratic districts. Figure U2 displays the calculations of each plan's number of Democratic districts under a uniform swing of +4.5%, which corresponds to a 52.42% statewide Democratic vote share. Figure U3 displays the calculations of each plan's number of Democratic districts under a uniform swing of +5.0%, which corresponds to a 52.92% statewide Democratic vote share.

**Figure U2:
 Number of Democratic House Districts Measured Using the 2010–2016 Election Composite
 With a +4.5% Uniform Swing, Corresponding to a 52.42% Statewide Democratic Vote Share
 (House Simulation Set 1)**

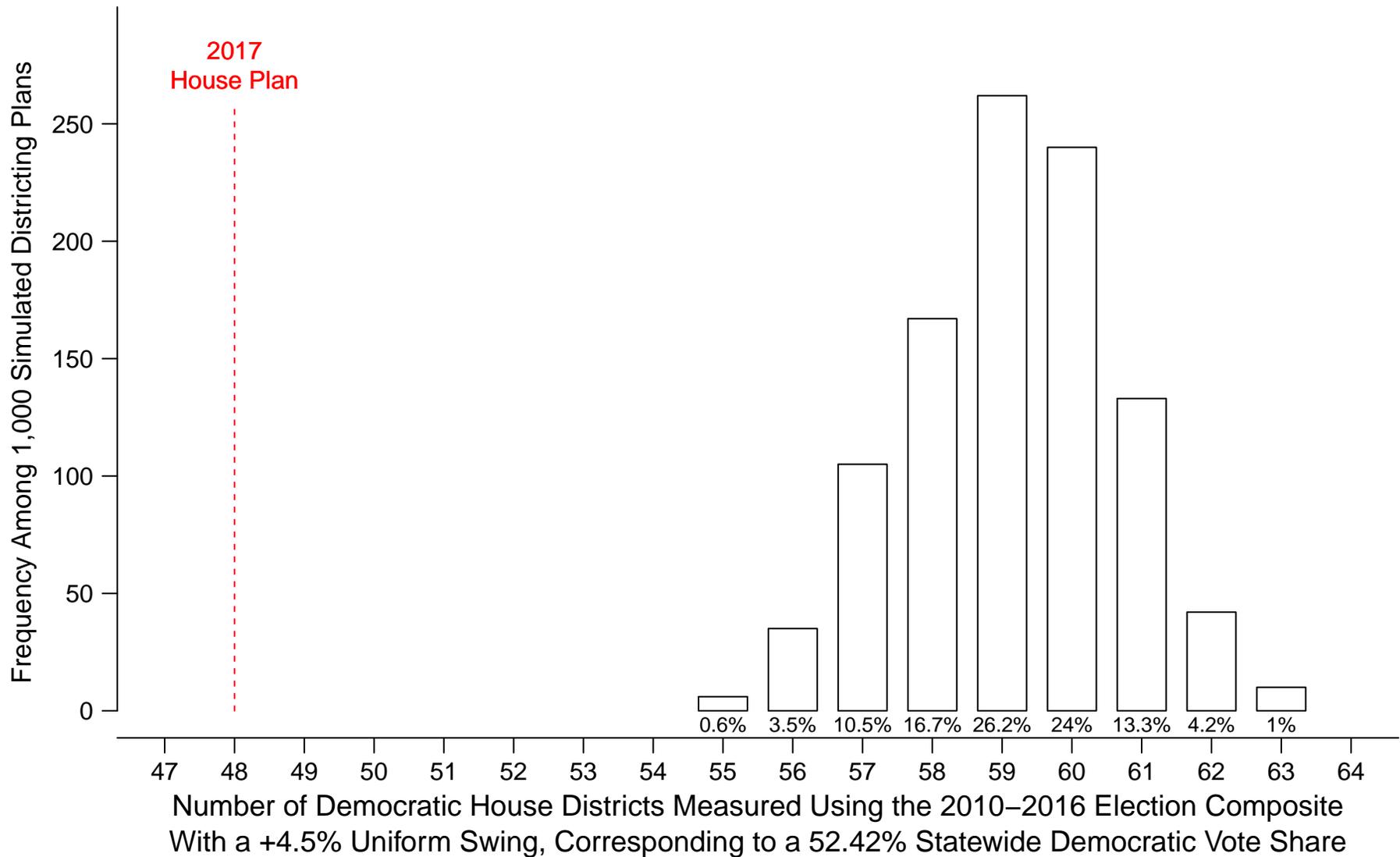
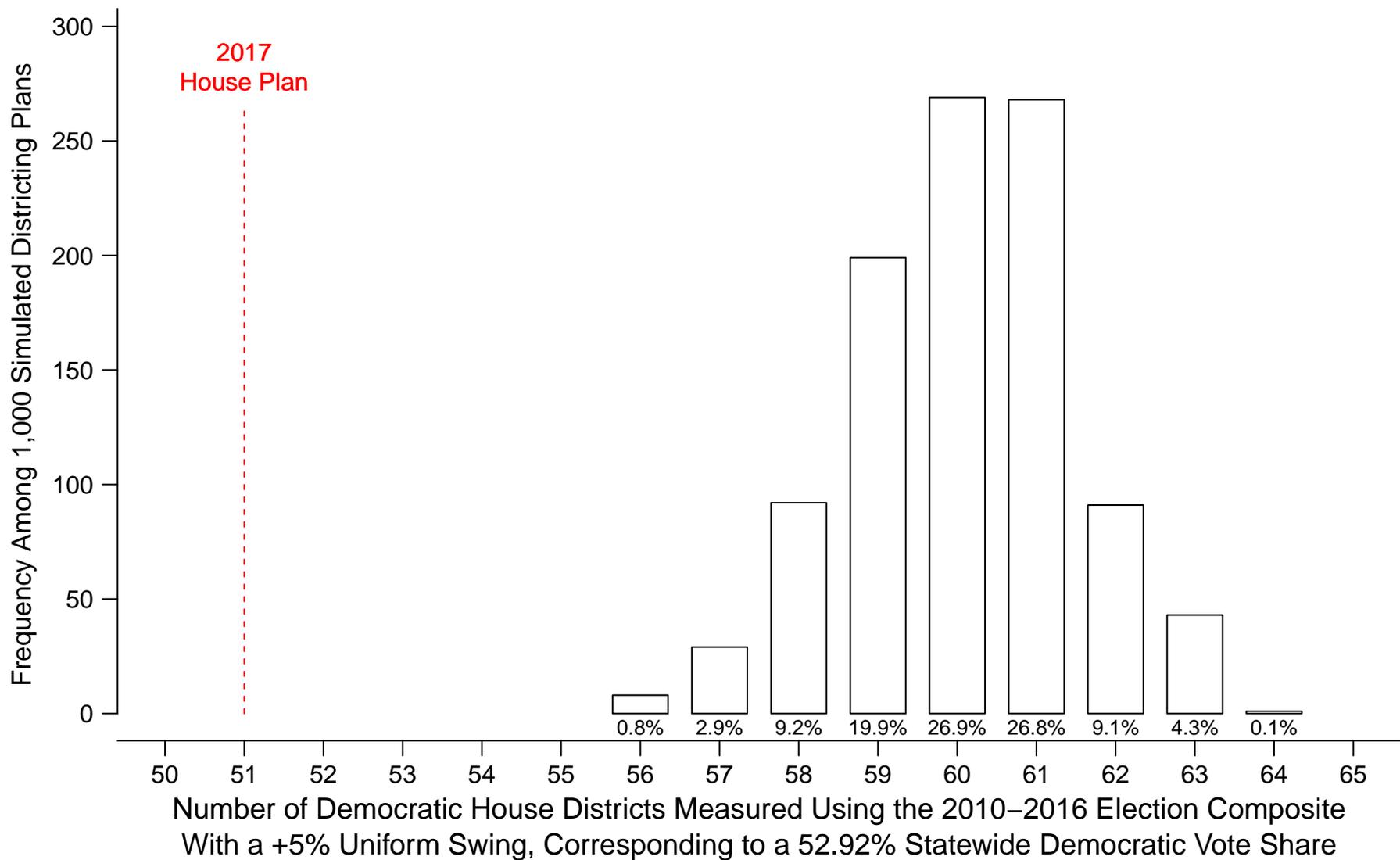


Figure U3:

Number of Democratic House Districts Measured Using the 2010–2016 Election Composite With a +5% Uniform Swing, Corresponding to a 52.92% Statewide Democratic Vote Share (House Simulation Set 1)

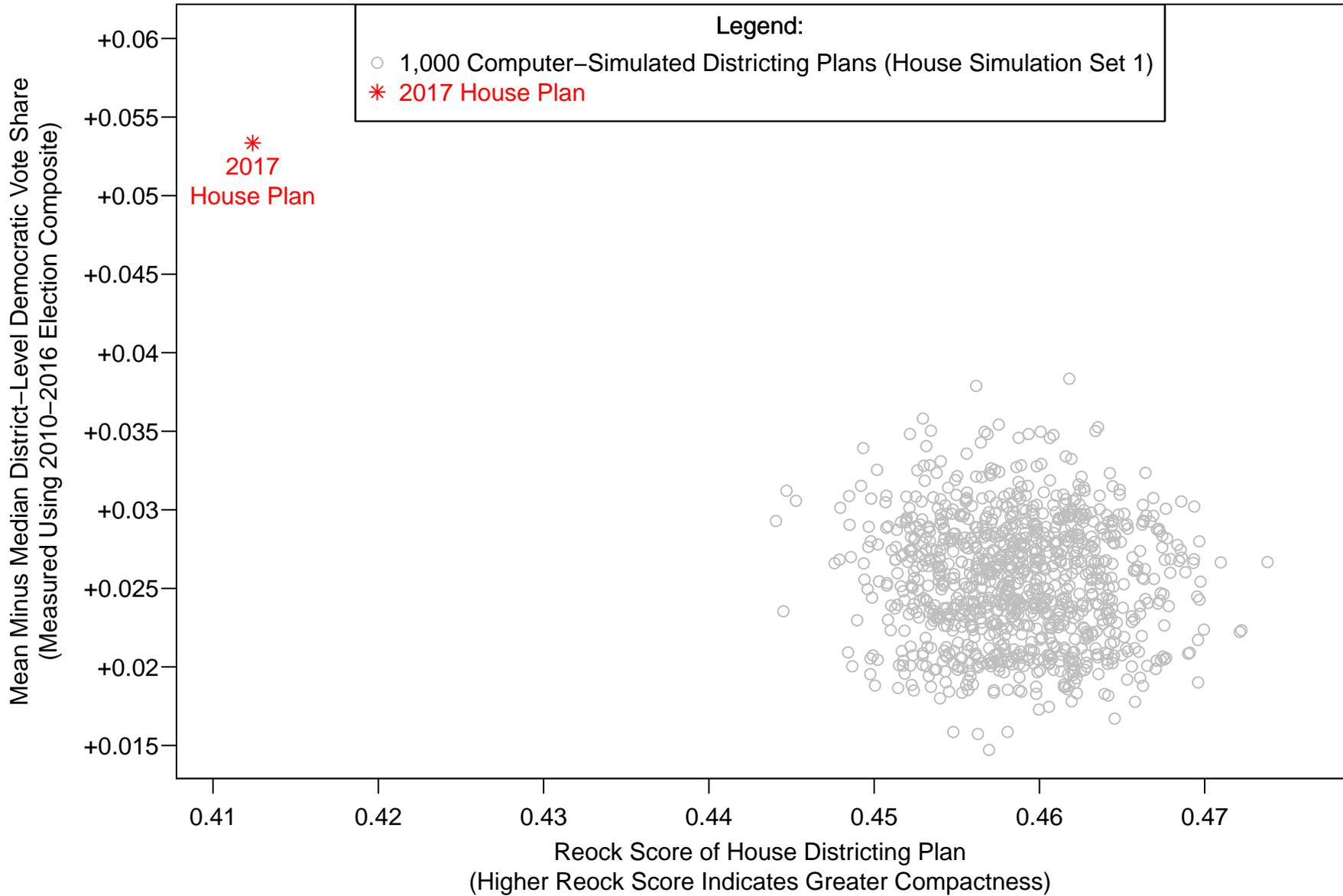


Mean-Median Difference: Analysis of the Mean-Median Difference confirms the partisan-outlying nature of the 2017 House Plan when compared to the computer-drawn plans in House Simulation Set 1. In Figure 3, the vertical axis measures the Mean-Median Difference of the 2017 House Plan and each simulated plan using the 2010-2016 Statewide Election Composite, while the horizontal axis measures the average Reock score of the districts within each plan, with higher Reock scores indicating more compact districts. In this Figure, each of the gray circles represents one of the 1,000 computer-simulated plans in House Simulation Set 1, while the red star represents the 2017 House Plan. Figure 3 illustrates that the 2017 House Plan's Mean-Median Difference is +5.3%, indicating that the median district is skewed significantly more Republican than the plan's average district. Figure 3 further indicates that this difference is an extreme statistical outlier compared to the 1,000 simulations in House Simulation Set 1. Indeed, the 2017 House Plan's +5.3% Mean-Median Difference is an outcome never observed across these 1,000 simulated plans. The 1,000 simulated plans all exhibit Mean-Median Differences ranging from +1.5% to +3.8%. In fact, the middle 50% of these computer-simulated plans have Mean-Median Differences ranging from +2.3% to +2.8%, indicating a much smaller degree of skew in the median district than occurs in the 2017 House Plan.

The fact that the 1,000 simulated plans in Figure 3 all produce a small, positive Mean-Median Difference certainly indicates that voter geography is modestly skewed in a manner that slightly benefits the Republicans in North Carolina House districting. This modest skew in the simulated districting plans may result partially from Democratic voters' tendency to cluster in large, urban areas of North Carolina, as I have explained in my previous academic research.⁷ The modest skew may also result from the county groupings that the General Assembly created under the 2017 House Plan, as my simulation algorithm simply follows the same county grouping boundaries used in the enacted plan. But more importantly, the range of this skew in the simulated plans, as shown in Figure 3, is always much smaller than the extreme +5.3% Mean-Median Difference observed in the 2017 House Plan. Hence, these results confirm the main finding that the 2017 House Plan creates an extreme partisan outcome that cannot be explained

⁷ Jowei Chen and Jonathan Rodden, 2013. "Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures" *Quarterly Journal of Political Science*, 8(3): 239-269; Jowei Chen and David Cottrell, 2016. "Evaluating Partisan Gains from Congressional Gerrymandering: Using Computer Simulations to Estimate the Effect of Gerrymandering in the U.S. House." *Electoral Studies*, Vol. 44, No. 4: 329-430.

Figure 3:
House Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Comparison of 2017 House Plan to 1,000 Simulated Plans on Compactness and Mean-Median Difference



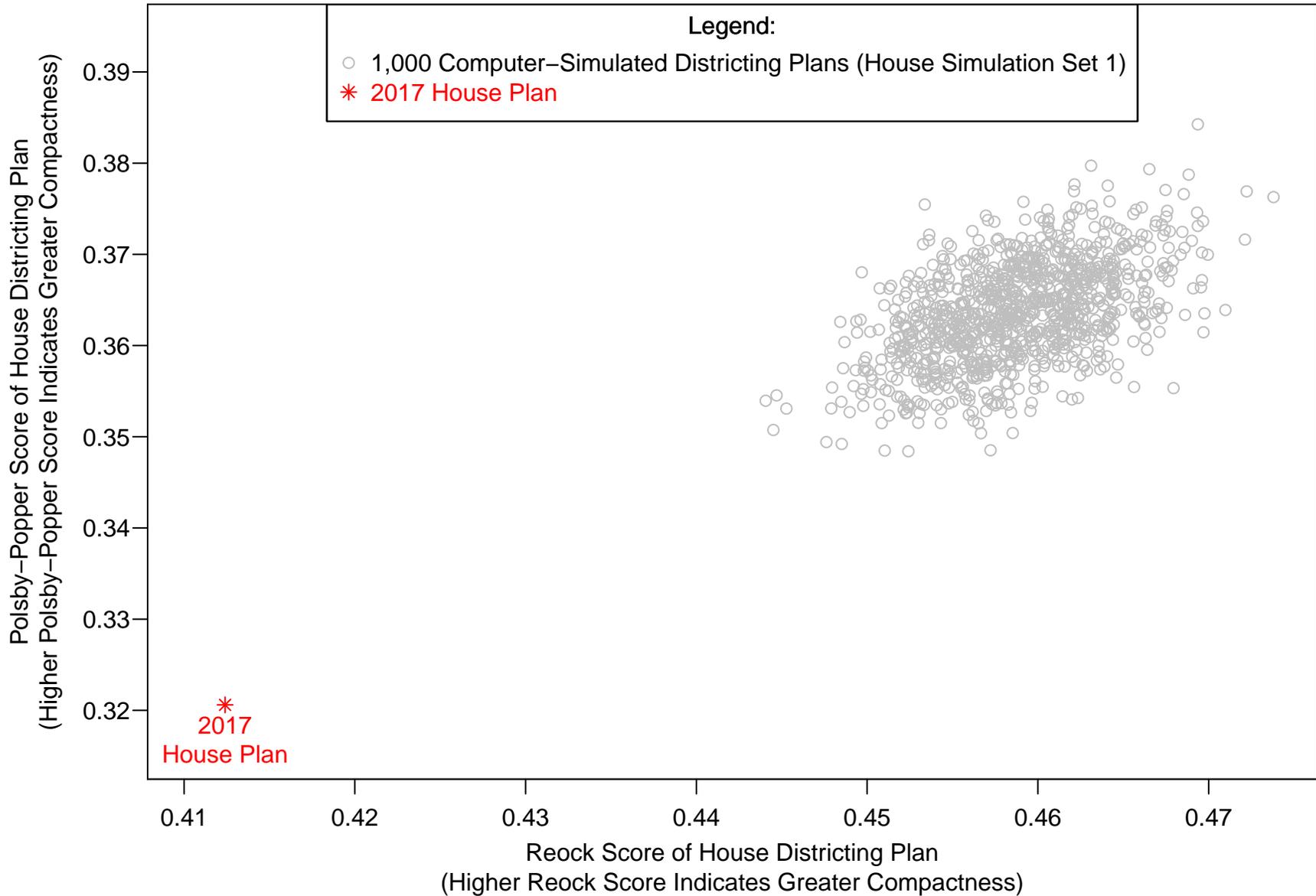
by North Carolina's voter geography or by the application the non-partisan districting criteria listed in the 2017 Adopted Criteria.

Was the 2017 House Plan produced with reasonable effort to draw compact districts? Figure 4 illustrates the compactness of the 1,000 simulated plans, compared against the compactness of the enacted 2017 House Plan. In this diagram, the horizontal axis depicts the average Reock score of the districts within each plan, while the vertical axis depicts the average Polsby-Popper score. Higher Reock scores and higher Polsby-Popper scores both indicate greater geographic compactness. Each gray circle in this diagram represents one of the 1,000 simulated plans, while the red star denotes the enacted 2017 House Plan. Figure 4 illustrates that the 2017 House Plan is significantly less geographically compact than every single one of the simulated plans in House Simulation Set 1, whether measured by average Reock or average Polsby-Popper scores. The simulated plans contain Reock scores ranging from 0.444 to 0.474, while the 2017 House Plan produces a Reock score of only 0.412. Similarly, the simulated plans have Polsby-Popper scores ranging from 0.348 to 0.384, while the 2017 House Plan produces a Polsby-Popper score of only 0.321. Hence, it is clear that the 2017 House Plan did not seek to draw districts that were as geographically compact as reasonably possible.

Did the 2017 House Plan make reasonable efforts to pursue any of the other non-partisan districting criteria outlined in the 2017 Adopted Criteria? Once again, the computer simulations are illuminating because they offer insight into the type and range of plans that would have emerged had reasonable efforts been made to adhere to the non-partisan portions of the 2017 Adopted Criteria. As detailed in Figure 5, the 2017 House Plan split far more municipalities than was reasonably necessary: The 1,000 computer-simulated plans split from 38 to 55 municipalities, while the 2017 House Plan splits 79 municipalities. Furthermore, as Figure 6 illustrates, the 2017 House Plan also split far more VTDs than was reasonably necessary: The 1,000 computer-simulated plans split from 6 to 18 VTDs, while the 2017 House Plan split 48 VTDs. Hence, it is clear that the 2017 House Plan did not seek to split as few municipalities and VTDs as reasonably possible.

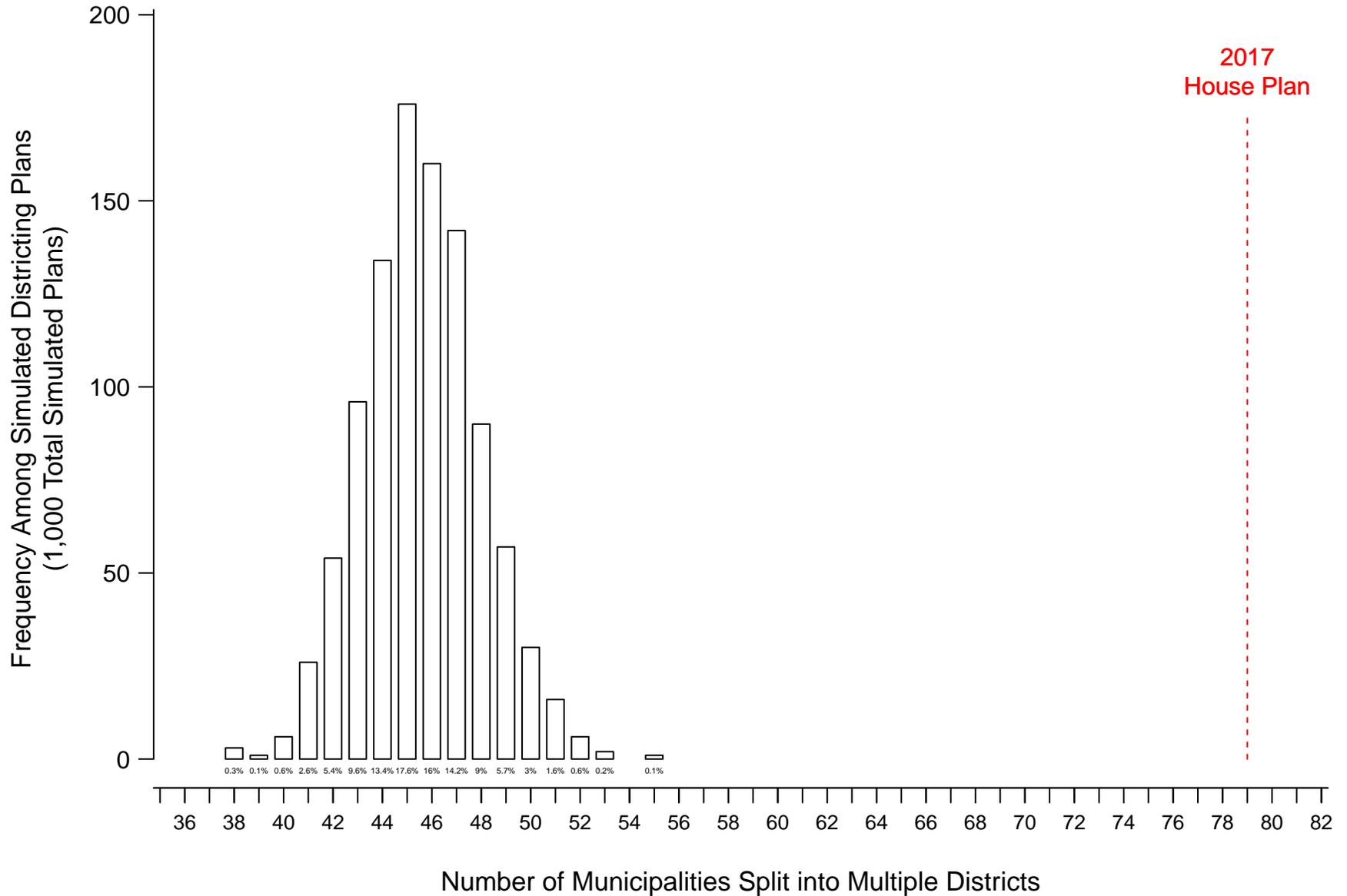
Why did the 2017 House Plan so significantly subordinate these non-partisan criteria of geographic compactness and minimizing VTD and municipality splits? The 2017 House Plan is entirely outside the range of the simulated maps with respect to both the partisan distribution of seats (Figures 2 and 3) and geographic compactness (Figures 3 and 4), in addition to splitting far

Figure 4:
House Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Comparison of 2017 House Plan Versus 1,000 Simulated Plans on Compactness

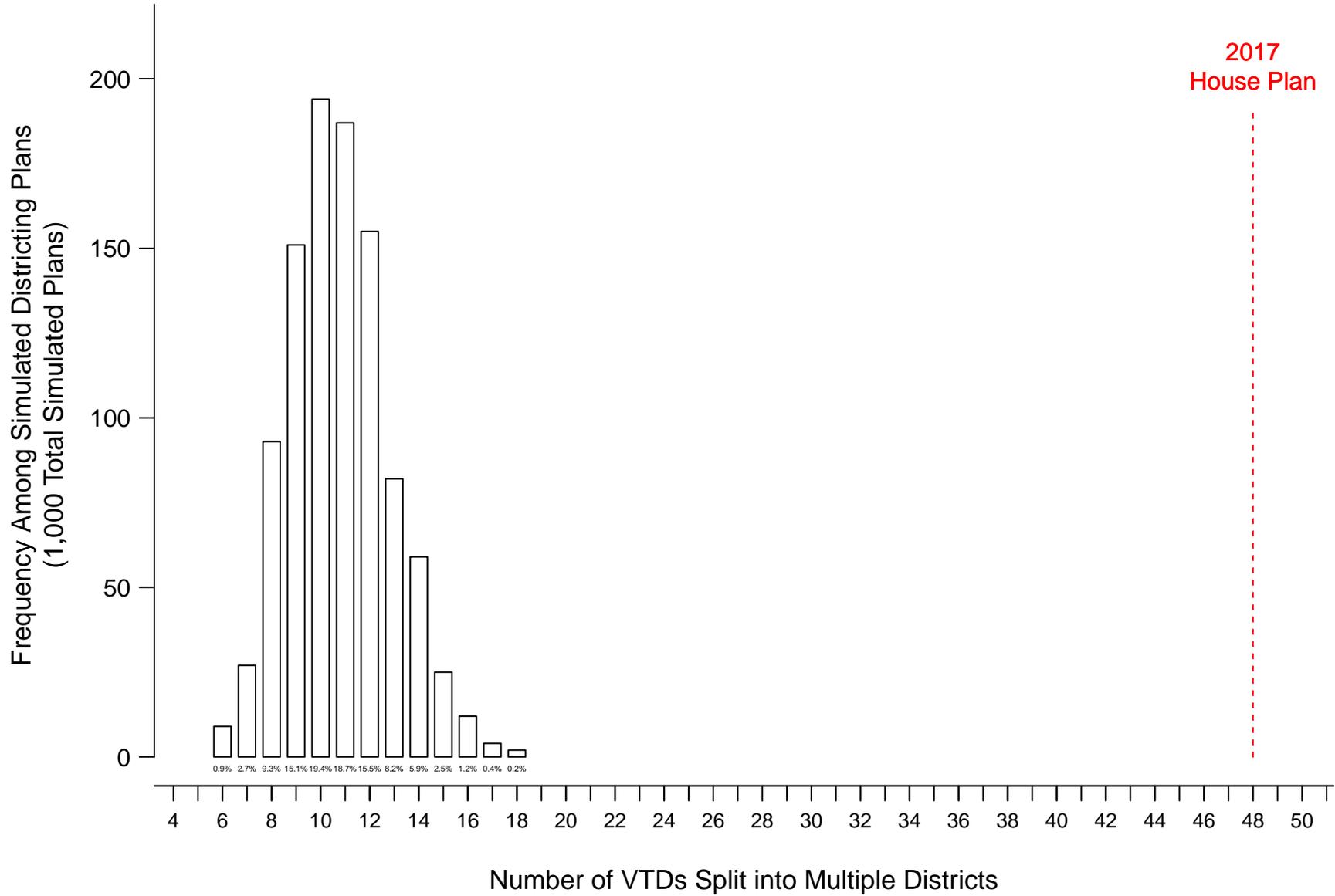


more municipalities (Figure 5) and VTDs (Figure 6) than would have occurred if the map-drawer had simply followed the non-partisan portions of the 2017 Adopted Criteria. Collectively, these findings suggest that the 2017 House Plan was drawn under a process in which a partisan goal – the skewing of districts in a pro-Republican direction and the creation of additional Republican districts – predominated over adherence to the non-partisan districting criteria described in the 2017 Adopted Criteria. The predominance of this extreme partisan goal subordinated the non-partisan, traditional districting considerations of minimizing VTD splits, following municipal boundaries, and drawing geographically compact districts.

**Figure 5:
House Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Split Municipalities in 2017 House Plan Versus 1,000 Simulated Plans**



**Figure 6:
House Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Split VTDs in 2017 House Plan Versus 1,000 Simulated Plans**



House Simulation Set 2:

Following Traditional Districting Criteria While Protecting Incumbent Representatives

In producing House Simulation Set 1, the computer algorithm ignored any considerations regarding the protection of incumbent House members or the pairing of incumbents within the same district. I initially ignored this portion of the 2017 Adopted Criteria because the intentional protection of incumbent House members during the redistricting process could cause indirect partisan consequences.

Among the 116 relevant incumbents holding office at the time of the original drawing of each of the 2017 House Plan districts, 68 incumbents (or 59%) were Republican, while only 48 incumbents were Democrats. These incumbents were elected from previous versions of North Carolina's House districts. As this slate of incumbents is heavily Republican and was elected from previous versions of North Carolina's House districts, an attempt to protect all incumbents would, in general, encourage the drawing of a plan with districts somewhat similar to the pre-enacted districts from which these incumbents had been previously elected, thus indirectly distorting the partisan distribution of voters across districts. Hence, I conducted the first set of simulations (House Simulation Set 1) with no efforts at incumbency protection in order to analyze the range of plans that could emerge from strict adherence to the non-partisan portions of the 2017 Adopted Criteria.

Nevertheless, I also sought to analyze whether the significant Republican bias created by the enacted 2017 House Plan could have simply resulted from an effort to protect the incumbent members of North Carolina's House of Representatives by not pairing two or more of them into the same district. I analyzed and evaluated this possible explanation by conducting a second set of districting simulations (House Simulation Set 2) that intentionally protect exactly as many incumbents as is mathematically possible within each county grouping while otherwise adhering to the same traditional districting criteria described earlier. Moreover, the computer algorithm was even instructed to protect the very same incumbents that are protected under the 2017 House Plan's districts, meaning that my simulations did not double-bunk any incumbent who was not double-bunked under the enacted plan. I found that even a districting process that intentionally protects as many incumbents as is possible (while also protecting the specific incumbents protected by the 2017 House Plan) does not explain the extreme Republican advantage created by the 2017 House Plan.

I began by identifying the 2017 House Plan districts that were drawn in a manner that protected incumbent House members from being paired with another incumbent. Specifically, I identified these protected House incumbents in the following three ways: First, within the House districts that were redrawn in 2017, I analyzed those House incumbents who were holding office when the General Assembly drew the 2017 House map. Second, Plaintiffs' counsel provided me with a list of those incumbents who had publicly announced their retirements before the enactment of the 2017 House Plan, and I removed these incumbents from consideration in my analysis. Furthermore, some House districts that were originally drawn in 2011 were not altered in the 2017 House Plan. Within these unaltered districts, I identified the incumbents holding office as of the 2011 redistricting process, since those were the incumbents whom the General Assembly would have been attempting to protect at the time those districts were drawn. In other words, for those House districts in the 2017 House Plan that were originally drawn in 2011 and not redrawn in 2017, I analyzed whether the incumbents holding office in 2011 were protected in those districts. In summary, the incumbents I considered in this analysis were only those Representatives who were holding office (and had not announced retirement plans) when their respective districts were originally drawn, which was either in 2011 or in 2017.

For the House districts drawn in 2011 and unchanged in 2017, there were 39 incumbents meeting the aforementioned criteria, and for the House districts redrawn in 2017, there were 77 incumbents meeting the aforementioned criteria. Thus, in total, I identified 116 House incumbents that the computer algorithm considered in producing House Simulation Set 2. Among these 116 total House incumbents, the relevant districts enacted in 2011 and 2017 protected 108 of the incumbents; the remaining eight incumbents were paired in districts containing more than one incumbent.

Having identified the 116 relevant incumbents for the House districts, I then conducted a second, separate set of simulations. House Simulation Set 2 prioritizes the protection of incumbents while otherwise pursuing the same non-partisan districting criteria as House Simulation Set 1. Specifically, I programmed the computer algorithm to guarantee the protection of the mathematically maximum possible number of incumbents within each county grouping. Additionally, I also required that the algorithm produce districts that protect, at a minimum, the same set of incumbents as the ones protected by the 2017 House Plan districts. In other words, the simulation algorithm attempted to protect even more total incumbents than the 2017 House

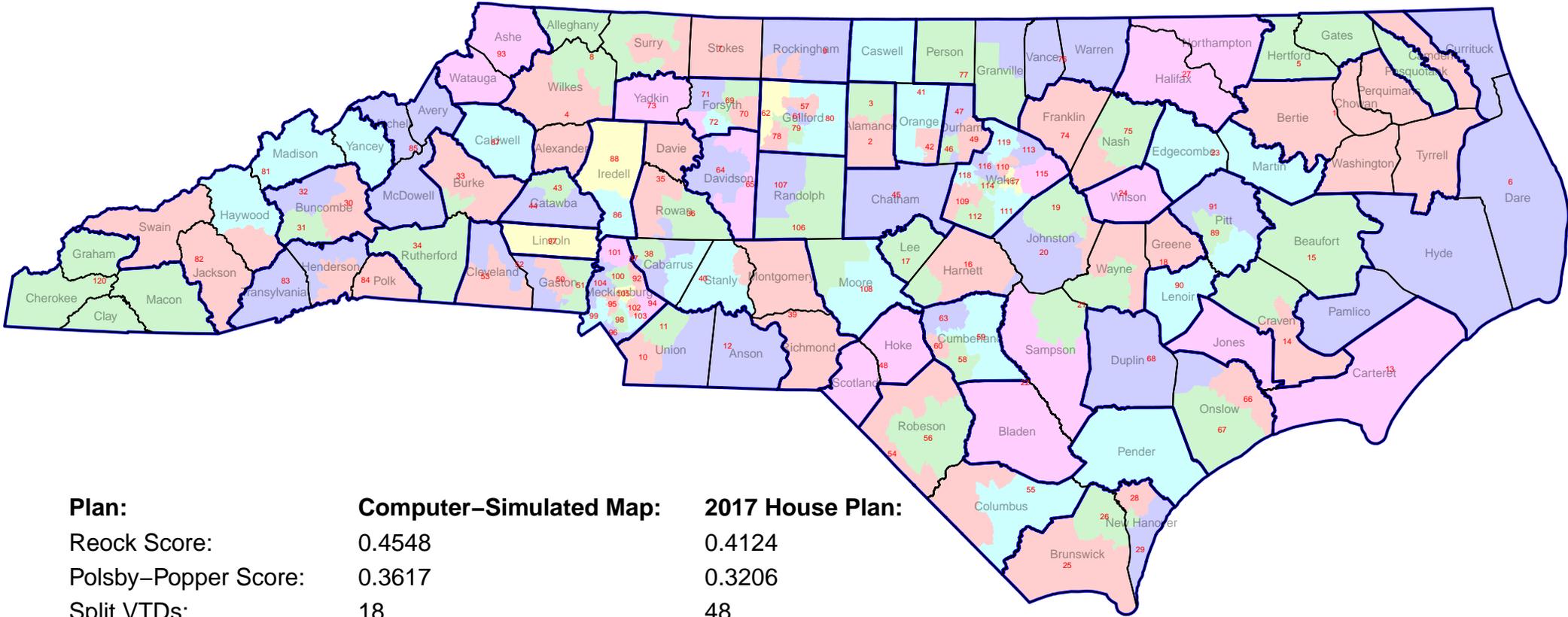
Plan did, but the algorithm was also required to protect, at minimum, the same 108 incumbents that were protected in the 2017 House Plan.

As an illustration of these two incumbency-protection requirements in House Simulation Set 2, consider the 2017 House Plan's districts 66, 67, 76, 77, 82, and 83 (all redrawn in 2017), which comprise the county grouping that includes Cabarrus, Davie, Montgomery, Richmond, Rowan, and Stanly Counties. This county grouping contained seven incumbents, but only six districts. Hence, not every incumbent could be protected. The mathematically maximum possible number of protected incumbents is five, with two remaining non-protected incumbents being paired together in a single district. The 2017 House Plan paired together Carl Ford and Larry Pittman in HD 83, while protecting five other incumbents: Representatives Barr (HD 67), Goodman (HD 66), Howard (HD 77), Johnson (82), and Warren (HD 76). Hence, in every simulated plan in House Simulation Set 2, the computer algorithm requires that: 1) At least five incumbents must be protected in this county grouping; and 2) those five incumbents must include Representatives Barr, Goodman, Howard, Johnson, and Warren. Effectively, in this case, these requirements imply that Representatives Ford and Pittman must be paired together in a single district, just as they are paired under the 2017 House Plan. This approach to protecting incumbents is an extremely conservative one because it not only maximizes the protection of incumbents, but it also defers to the enacted plans in terms of the precise set of incumbents who are protected.

Aside from these two requirements, the computer algorithm gives no consideration to the partisanship of the incumbents that are protected or not protected under each simulated plan. And beyond this intentional protection of incumbents, House Simulation Set 2 otherwise prioritizes the same seven non-partisan traditional districting criteria followed in the first set of simulations while again ignoring any other political considerations beyond incumbent protection.

As an example of the maps produced by this algorithm, Figure 7 illustrates the final of the 1,000 simulated districting plans produced by the computer algorithm in House Simulation Set 2. Descriptions of the 1,000 simulated maps in House Simulation Set 2 appear in the third column of Table 5. In addition to protecting the same 108 incumbents protected by the enacted plan, all 1,000 of these simulated plans also protect two additional House incumbents in Buncombe County who were not protected by the enacted plans: Susan Fisher (Democrat) and Patsy Keever (Democrat). Representatives Fisher and Keever were paired into HD 114 in 2011

**Figure 7:
Example of a Computer–Simulated House Map
From House Simulation Set 2 (Following Non–Partisan Redistricting Criteria and Avoiding Incumbent Pairings)**



Plan:	Computer–Simulated Map:	2017 House Plan:
Reock Score:	0.4548	0.4124
Polsby–Popper Score:	0.3617	0.3206
Split VTDs:	18	48
Split Municipalities:	49	79
Mean–Median Difference:	+2.26%	+5.33%
Democratic Districts:	49	42

(District partisanship is measured using the 2010–2016 Statewide Election Composite)

Legend:

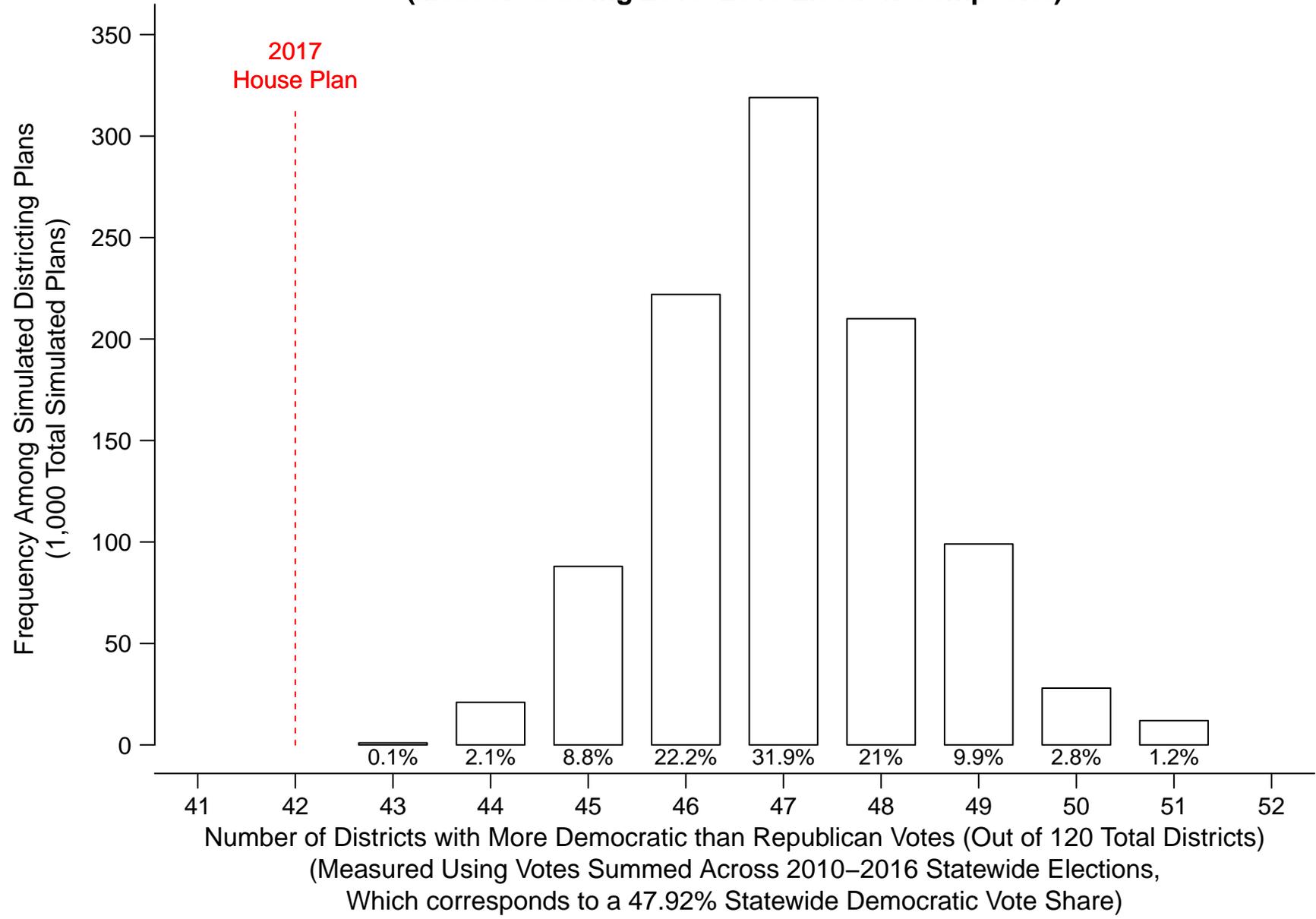
- County Grouping Boundaries
- County Boundaries
- Computer–Simulated House Districts (Including frozen districts from the 2017 House Plan) Numbered from 1 to 120

(this district was unchanged in 2017), but all 1,000 simulations in House Simulation Set 2 place them into separate districts with no pairing of any other incumbent in Buncombe County. Moreover, these 1,000 simulations also produced significantly more compact districts (whether measured using Reock or Polsby-Popper Score) while splitting significantly fewer VTDs than the 2017 House Plan's districts in Buncombe County. Together, these findings suggest that the General Assembly unnecessarily paired the two Democratic representatives (Fisher and Kever) together in drawing the three enacted House districts in Buncombe County.

Moreover, the protection of the maximum possible number of incumbents in House Simulation Set 2 was achieved without any increase in the number of county traversals, with only slight increases in the number of split municipalities (Figure 11) and split VTDs (Figure 12) and with only very slight decreases in the geographic compactness of the simulated districts (Figure 10). Figure 10 illustrates that the 2017 House Plan is still significantly less compact than every single one of the 1,000 simulations in House Simulation Set 2, using both the Reock and Polsby-Popper measures of compactness. Figure 11 illustrates that the 2017 House Plan's splitting of 79 municipalities is significantly more than in every single one of the 1,000 simulated plans, which only split from 44 to 61 municipalities. Figure 12 illustrates that the 2017 House Plan's splitting of 48 VTDs is significantly more than in every single one of the 1,000 simulated plans, which only split from 7 to 20 VTDs. Altogether, these simulation results illustrate that the 2017 Adopted Criteria criterion of not pairing multiple incumbents can be achieved without significantly subordinating any of the non-partisan traditional districting criteria listed in the Adopted Criteria. The 2017 House Plan, however, clearly subordinated the non-partisan districting criteria of geographic compactness, avoiding VTD splits, and avoiding municipality splits.

Does the protection of House incumbents make the 2017 House Plan's Republican partisan bias an outcome that could have plausibly emerged from a redistricting process adhering to non-partisan criteria? Figure 8 illustrates the distribution of partisan seats across the 1,000 simulated plans, with partisanship measured using the 2010-2016 Statewide Election Composite. This Figure illustrates that the partisan distribution of seats in plans under House Simulation Set 2 is nearly identical to the partisan distribution of House Simulation Set 1, which ignored incumbency protection. When the maximum possible number of incumbents is protected, the simulation algorithm still produces plans that mostly range from 46 to 48 Democratic districts

Figure 8:
House Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Avoiding Incumbent Pairings):
Democratic-Favoring Districts in 2017 House Plan Versus 1,000 Simulated Plans
(Measured Using 2010-2016 Election Composite)



(with a full range of 43 to 51 Democratic districts), as measured by the 2010-2016 Statewide Election Composite. The 2017 House Plan's creation of only 42 Democratic districts is an outcome never achieved in House Simulation Set 2. Nor is the 2017 House Plan's creation of a +5.53% Mean-Median Difference an outcome ever observed in a single one of these 1,000 simulations (Figure 9). Figures U4, U5, and U6 also perform the same uniform swing calculations as presented earlier for House Simulation Set 1; these uniform swing calculations confirm that under uniform swings that would allow Democrats to win 60 or more House districts in the computer-simulated plans, the 2017 House Plan would contain significantly fewer than 60 Democratic districts.

Hence, we are able to conclude with extremely high statistical certainty that even the strictest adherence to the 2017 Adopted Criteria's mandate of protecting incumbents, combined with adherence to the other non-partisan portions of the 2017 Adopted Criteria, does not cause or explain the extreme degree of Republican advantage exhibited by the 2017 House Plan. Instead, the 2017 House Plan was drawn under a process in which a partisan goal – the skewing of districts in a pro-Republican direction and the creation of additional Republican districts – predominated over adherence to the non-partisan districting criteria described in the 2017 Adopted Criteria.

Figure 9:
House Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Avoiding Incumbent Pairings):
Comparison of 2017 House Plan to 1,000 Simulated Plans on Compactness and Mean-Median Difference

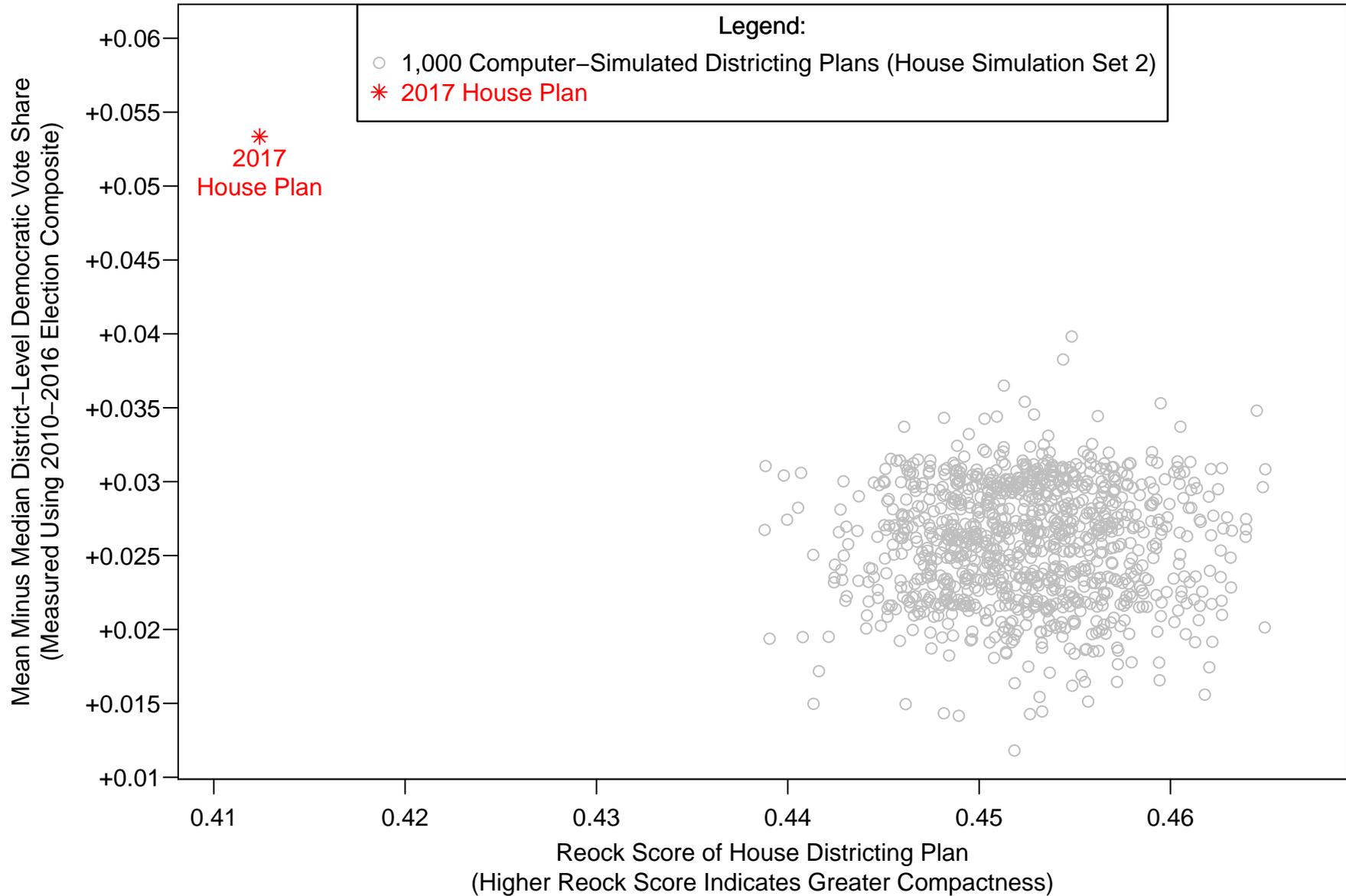


Figure 10:
House Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Avoiding Incumbent Pairings):
Comparison of 2017 House Plan Versus 1,000 Simulated Plans on Compactness

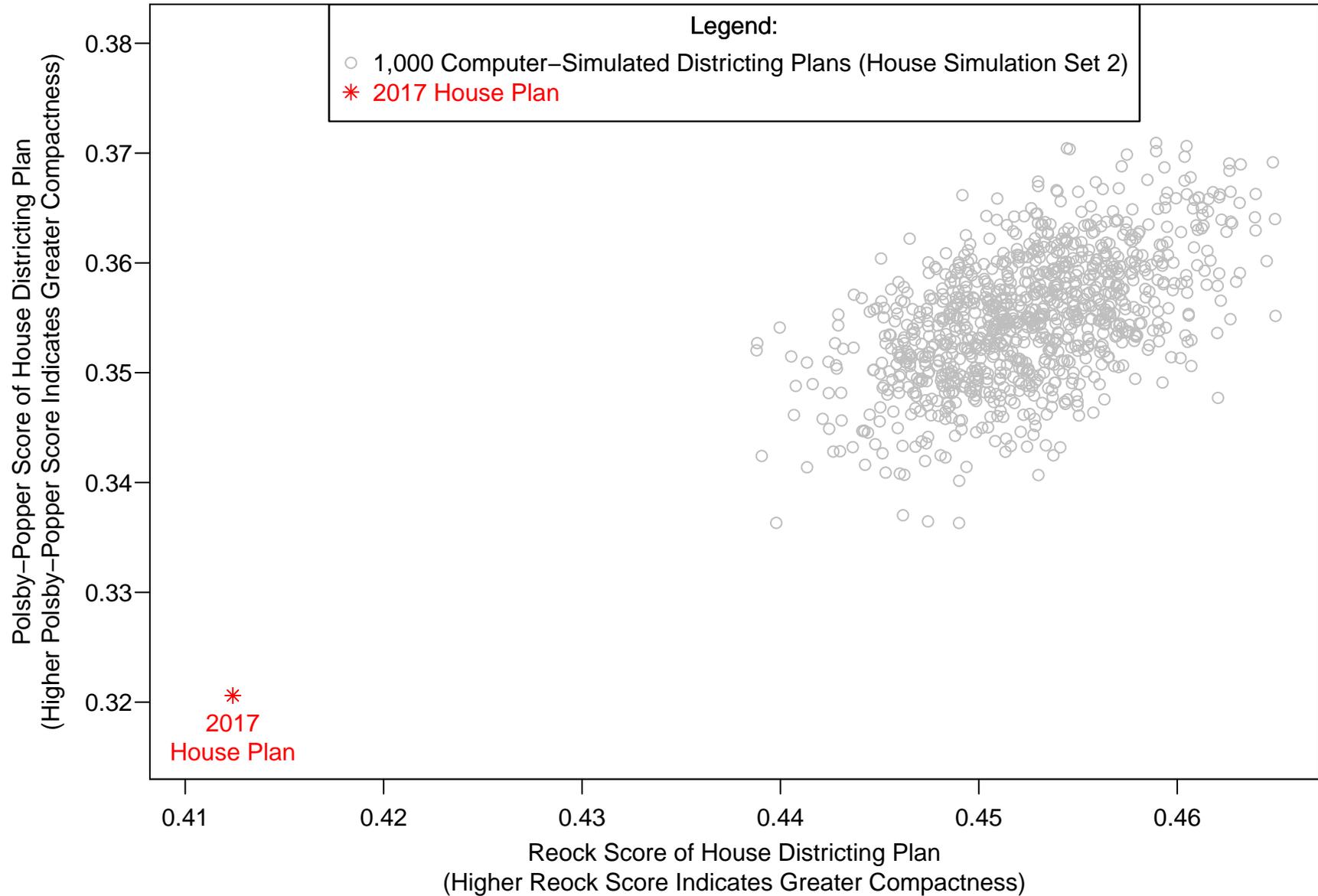
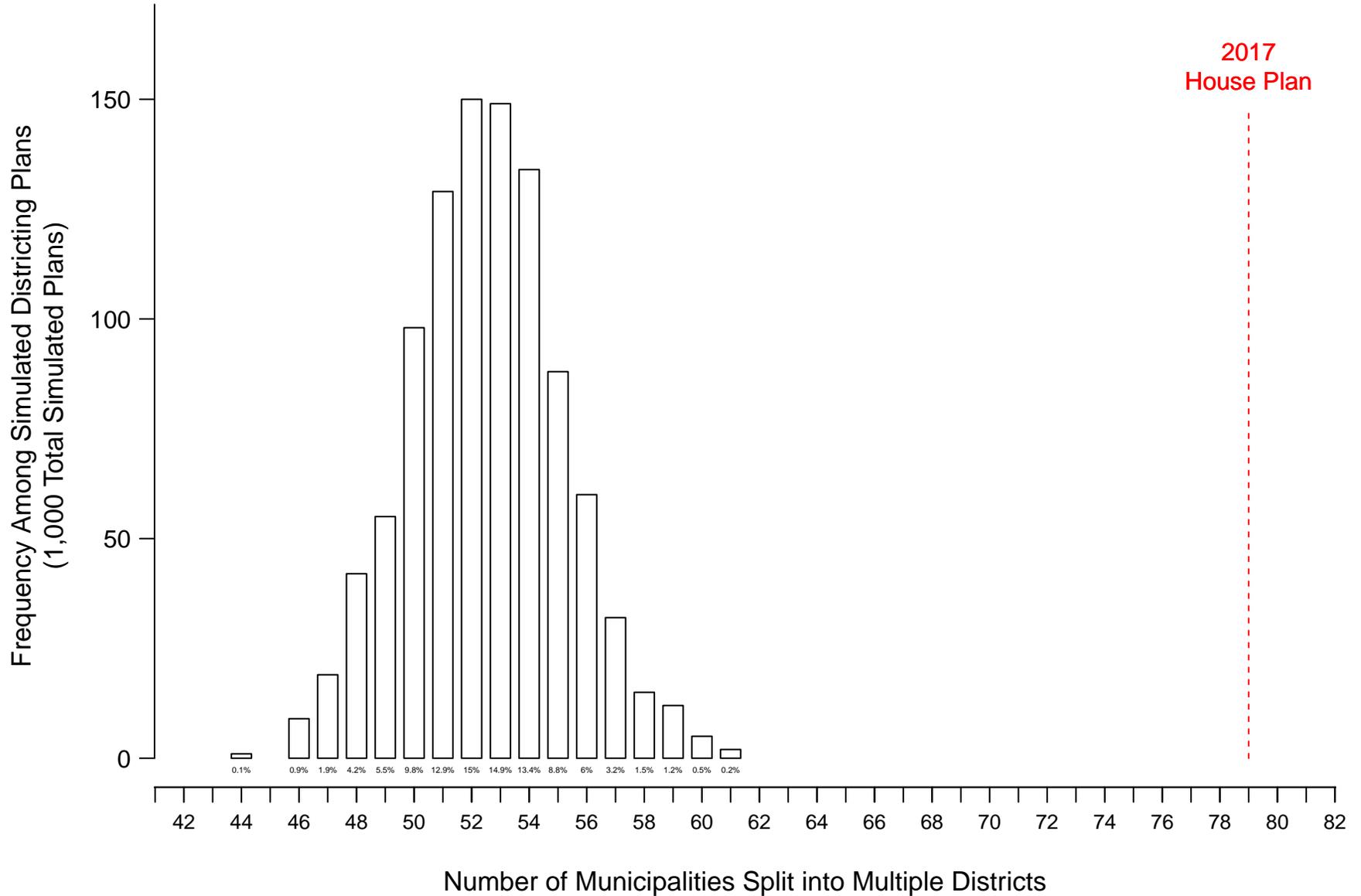


Figure 11:
House Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Avoiding Incumbent Pairings):
Split Municipalities in 2017 House Plan Versus 1,000 Simulated Plans



**Figure 12:
House Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Avoiding Incumbent Pairings):
Split VTDs in 2017 House Plan Versus 1,000 Simulated Plans**

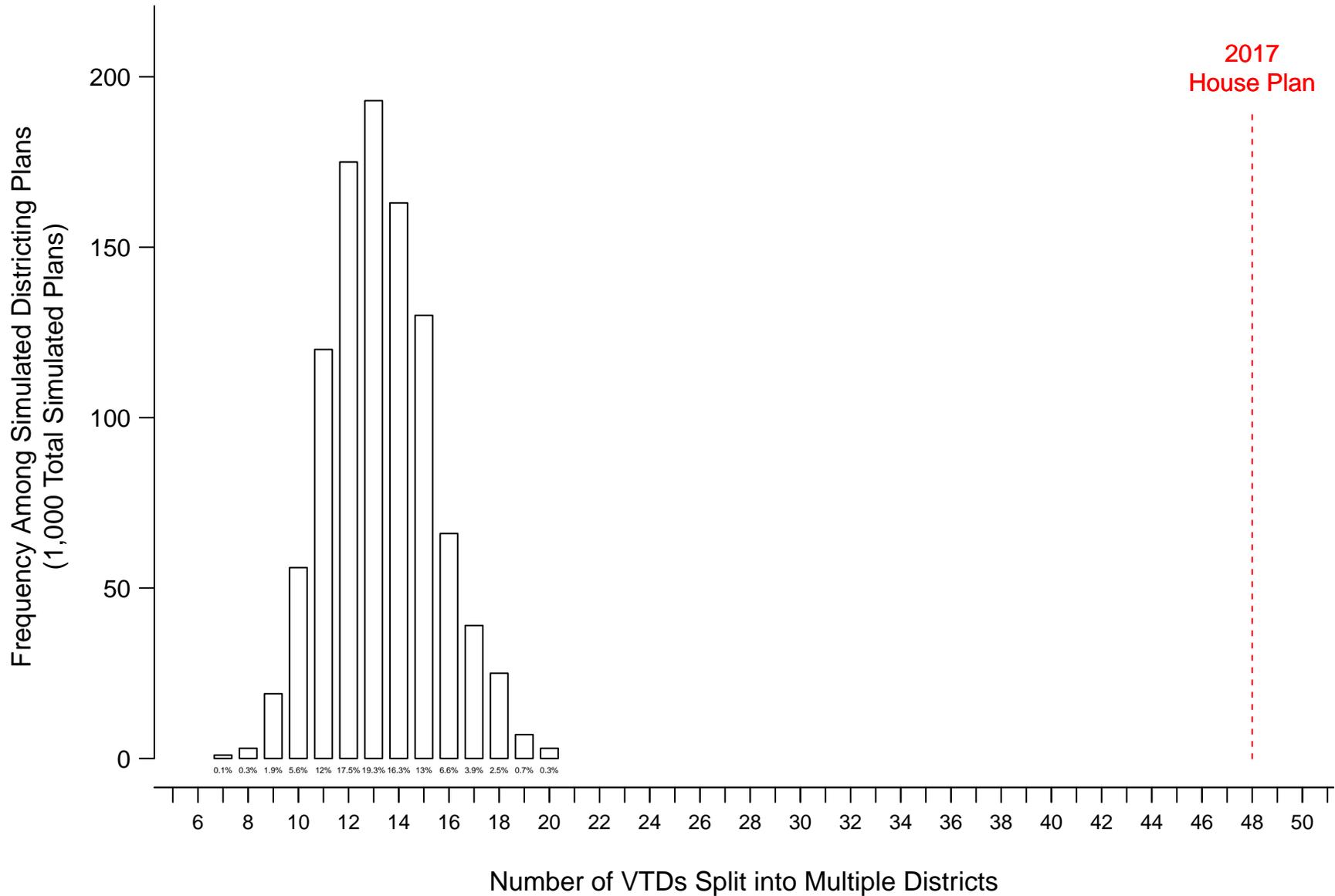
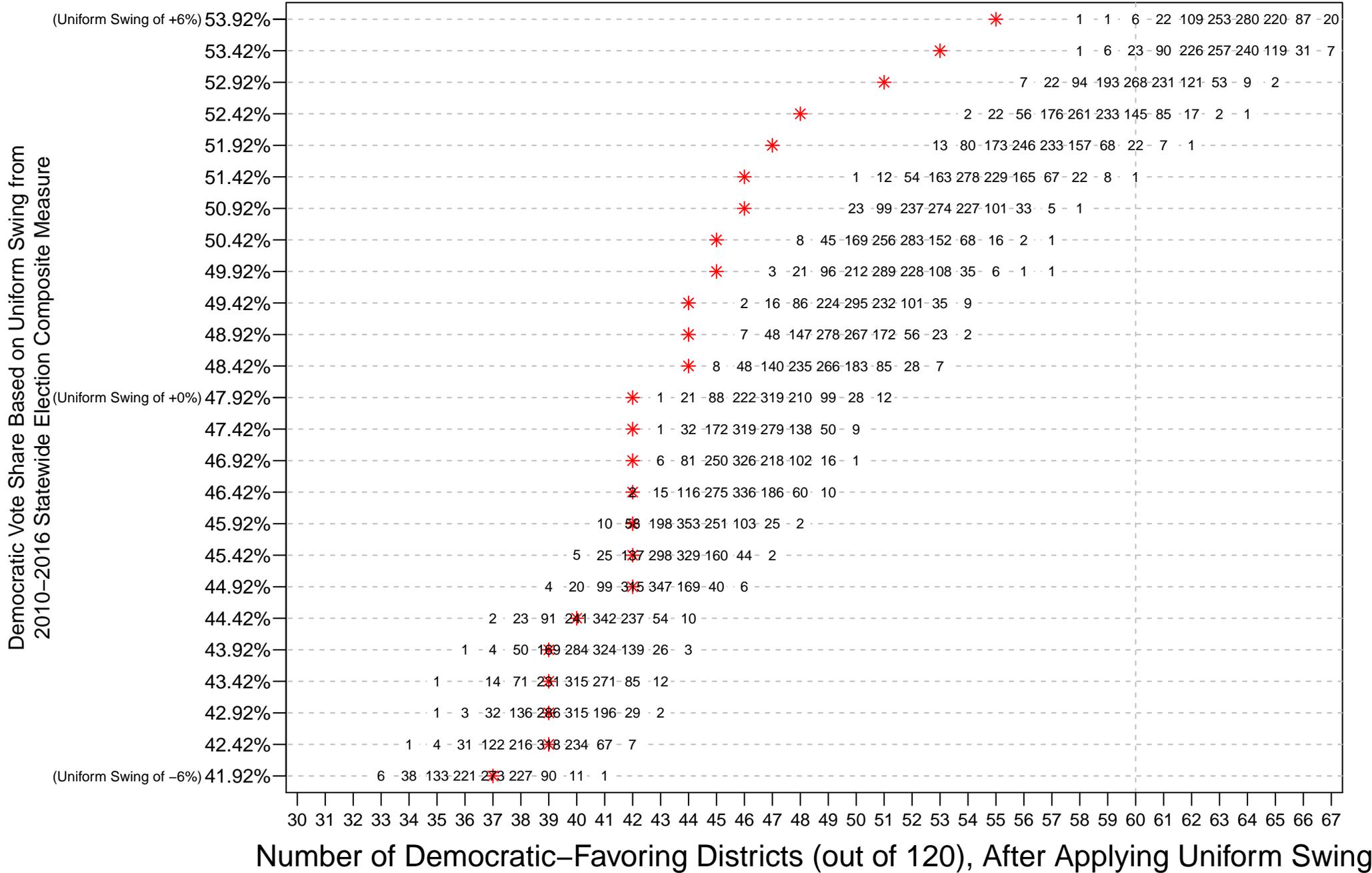


Figure U4: Number of Democratic Districts Under Alternative Uniform Swings in House Simulation Set 2 Plans



(Numbers in this figure report the number of simulated plans (out of 1,000) that would contain a particular number of Democratic districts (listed along the horizontal axis) under each uniform swing condition (listed in the left margin). Red stars denote calculations for the 2017 House Plan.)

**Figure U5:
 Number of Democratic House Districts Measured Using the 2010–2016 Election Composite
 With a +4.5% Uniform Swing, Corresponding to a 52.42% Statewide Democratic Vote Share
 (House Simulation Set 2)**

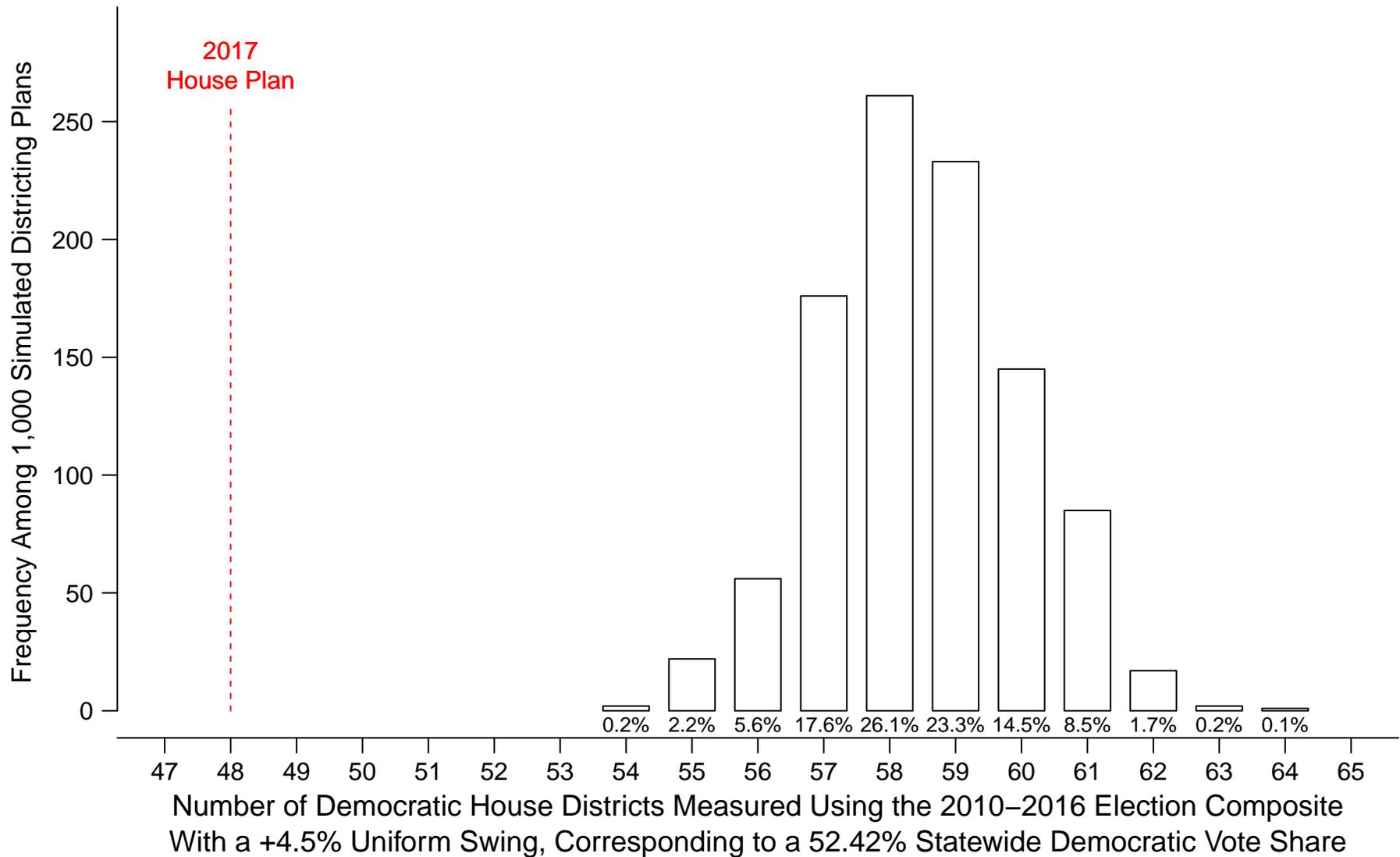
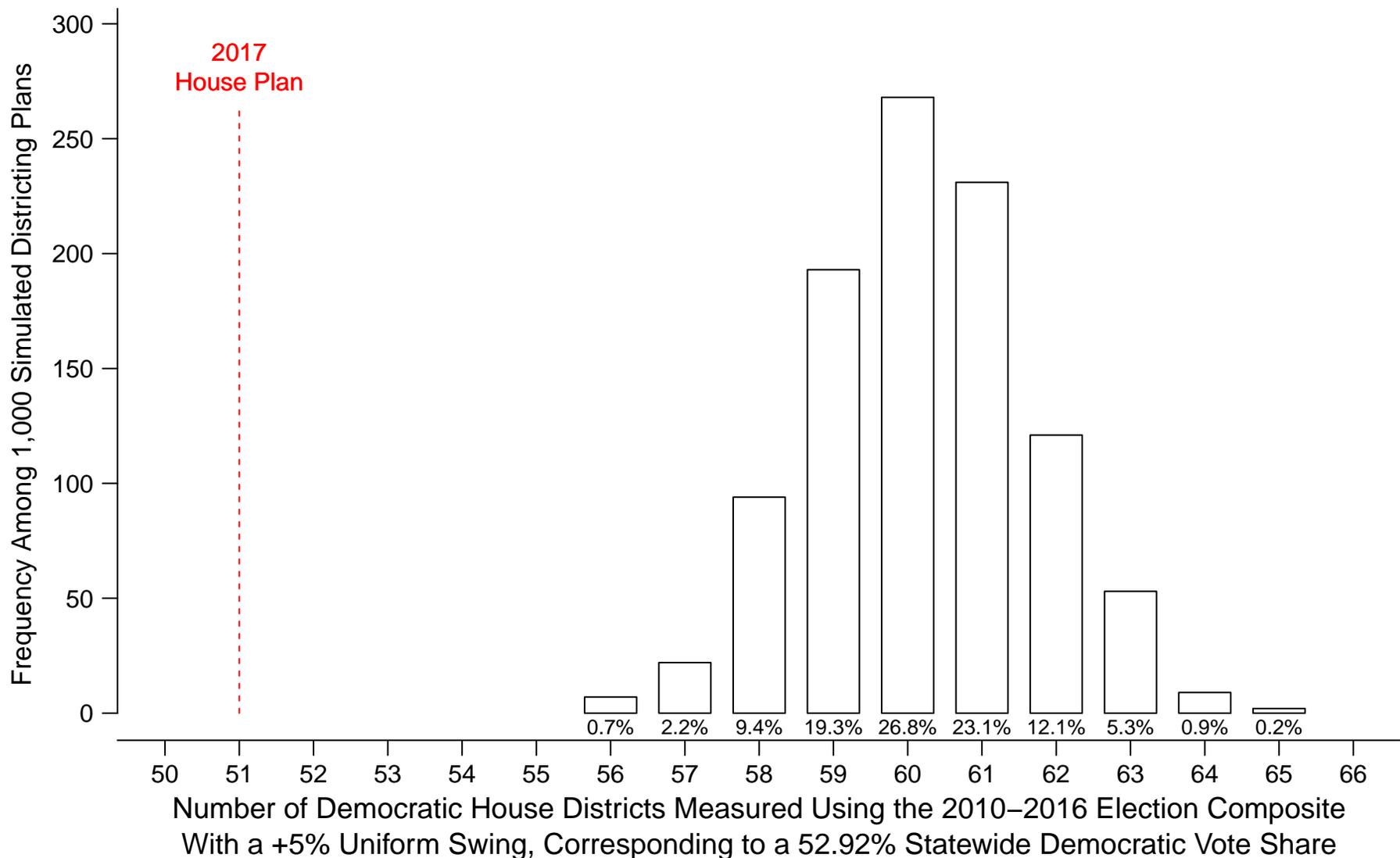


Figure U6:

Number of Democratic House Districts Measured Using the 2010–2016 Election Composite With a +5% Uniform Swing, Corresponding to a 52.92% Statewide Democratic Vote Share (House Simulation Set 2)



Senate Simulation Set 1:

Following Traditional Districting Criteria with No Incumbent Protection

I analyzed the 2017 Senate Plan using the same methodology I used to analyze the 2017 House Plan. I generated two sets of 1,000 simulated plans and compared the 2017 Senate Plan to each of these two sets of simulated plans.

To create Senate Simulation Set 1, I conducted a first set of 1,000 simulations in which North Carolina Senate plans were drawn to optimize on the seven non-partisan, traditional districting criteria described previously: population equality, contiguity, following county groupings, avoiding county splits and traversals, geographic compactness, avoiding VTD splits, and avoiding municipal splits. Table 6 details how the 2017 Senate Plan compares to the simulated plans in Senate Simulation Set 1 and Set 2 with respect to these various districting criteria (Senate Simulation Set 2 is discussed in further detail below). Figure 13 illustrates the final of the 1,000 simulated Senate districting plans produced by the computer algorithm in Senate Simulation Set 1.

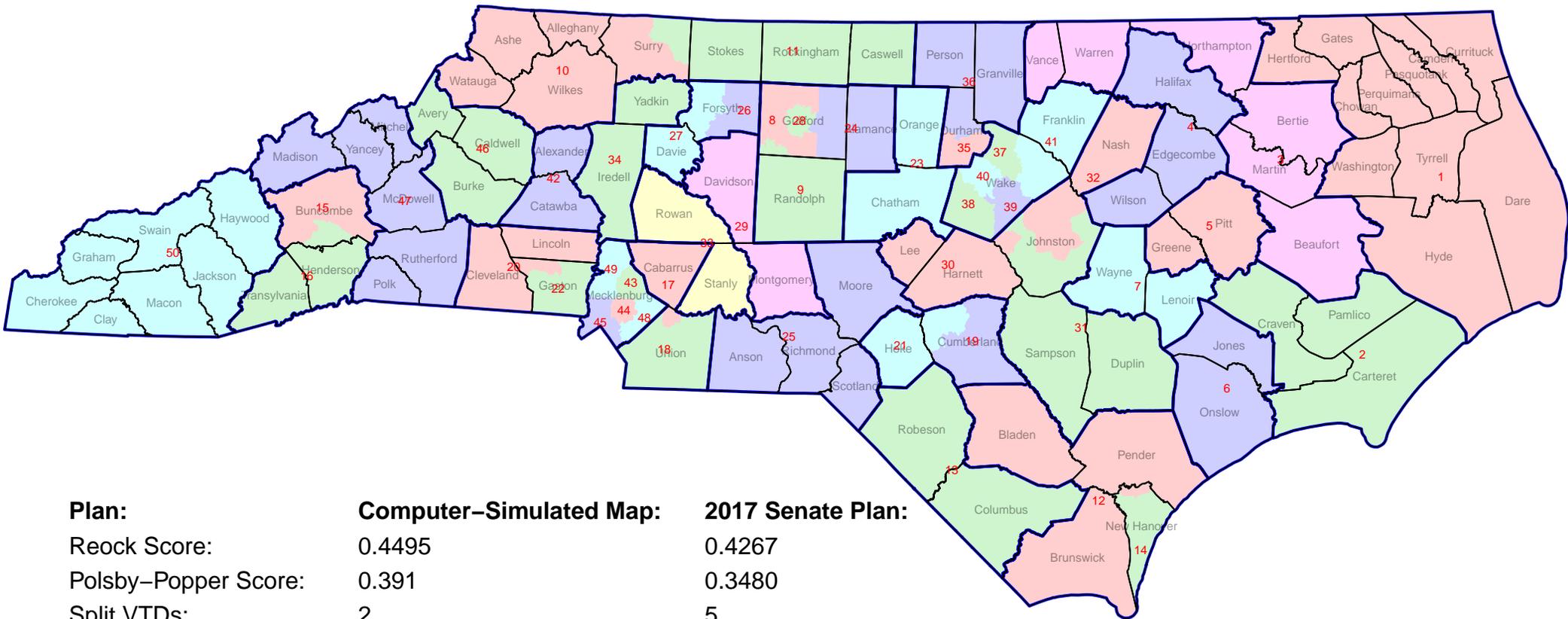
Number of Democratic and Republican Districts: Figure 14 compares the partisan breakdown of the simulated plans to that of the 2017 Senate Plan. Specifically, Figure 14 uses the 2010-2016 Statewide Election Composite, which corresponds to a 47.92% statewide Democratic vote share, to measure the number of Democratic-leaning districts created in each of the 1,000 simulated plans. As measured using the 2010-2016 Statewide Election Composite, every one of the simulated plans create from 19 to 21 Democratic districts out of 50 total districts. In contrast, the enacted 2017 Senate plan contains only 18 Democratic districts, using the same 2010-2016 Statewide Election Composite. The 1,000 simulations do not produce a single plan that results in only 18 Democratic districts, the outcome observed in the 2017 Senate Plan. I thus conclude with extremely high statistical certainty that the enacted Senate plan created a pro-Republican partisan outcome that would have been extremely unlikely to occur under a districting process adhering to non-partisan traditional criteria.

As noted earlier, the ten elections included in the 2010-2016 Statewide Election Composite generally occurred in election years and in electoral environments that were relatively favorable to Republicans across the country (in particular, 2010, 2014, and 2016). Hence, the projected number of Democratic seats would be greater in the computer-simulated plans if one analyzed results from a statewide election whose outcome was more partisan-balanced or even

Table 6: Summary of the Enacted 2017 Senate Plan and Senate Simulation Sets 1 and 2:

	2017 Senate Plan:	Senate Simulation Set 1:	Senate Simulation Set 2:
Description:	Current Enacted Plan	Simulated Senate maps following only traditional districting criteria	Simulated Senate maps that: 1) Protect the maximum number of incumbents in each grouping; 2) Protect at least the same incumbents who were protected in the 2017 Senate Plan; and 3) Otherwise follow non-partisan traditional districting criteria.
Total Number of Simulated Plans:		1,000 simulated maps	1,000 simulated maps
Number of Split Municipalities:	25	8 to 12	10 to 16
Number of Split VTDs:	5	0 to 3	0 to 3
Average Reock Score (Compactness):	0.427	0.438 to 0.460	0.433 to 0.458
Average Polsby-Popper Score (Compactness):	0.348	0.365 to 0.398	0.357 to 0.389
Mean-Median Difference:	+0.034	+0.010 to +0.029	+0.008 to 0.028
Democratic Districts (using 2010-2016 Statewide Election Composite, which corresponds to a 47.92% statewide Democratic vote share):	18 (out of 50 districts)	19 (321 simulation) 20 (508 simulations) 21 (171 simulations)	19 (250 simulation) 20 (647 simulations) 21 (98 simulations) 22 (5 simulations)

**Figure 13:
Example of a Computer–Simulated Senate Map
From Senate Simulation Set 1 (Following Only Non–Partisan Redistricting Criteria)**



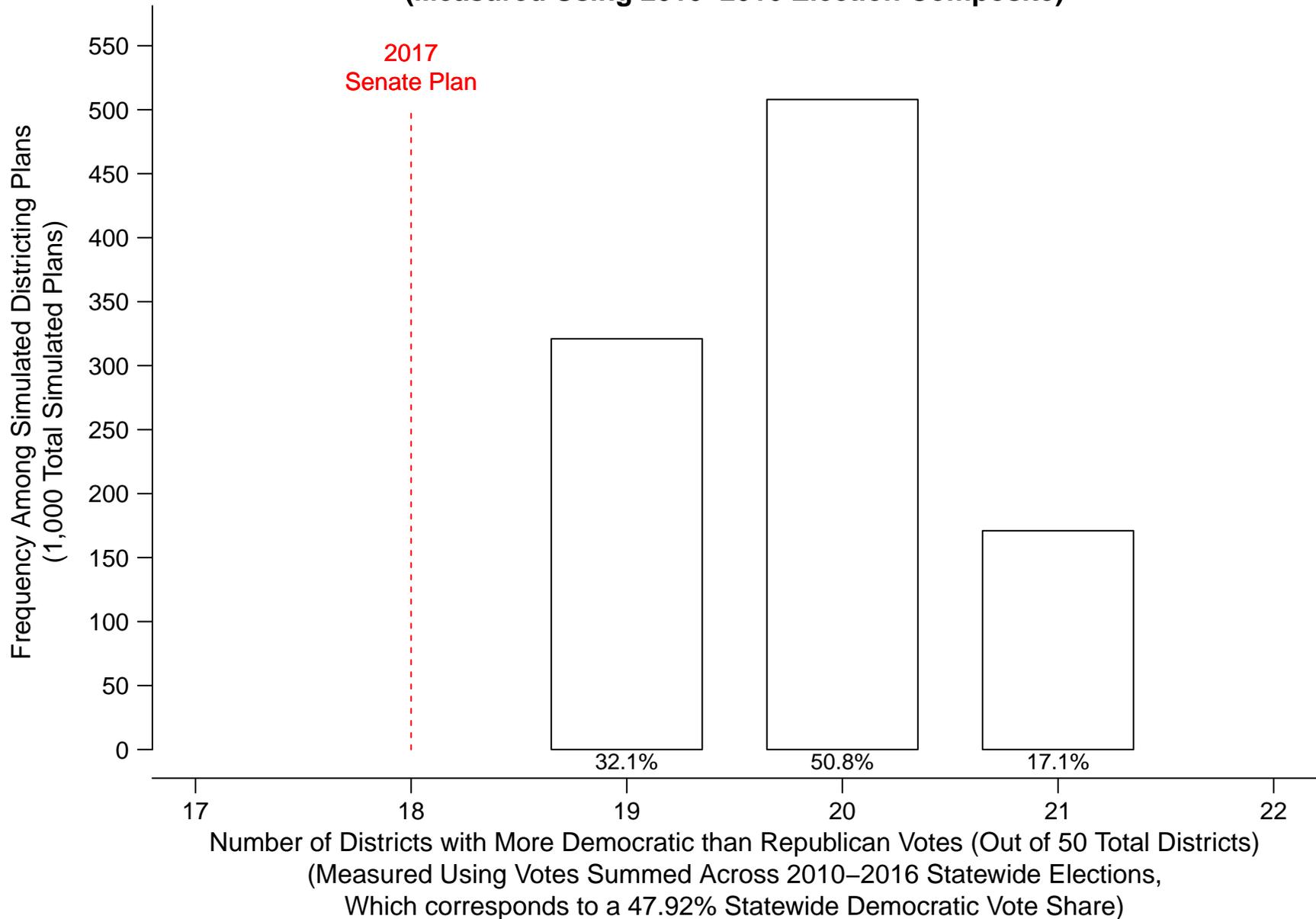
Plan:	Computer–Simulated Map:	2017 Senate Plan:
Reock Score:	0.4495	0.4267
Polsby–Popper Score:	0.391	0.3480
Split VTDs:	2	5
Split Municipalities:	10	25
Mean–Median Difference:	+1.62%	+3.4%
Democratic Districts:	20	18

(District partisanship is measured using the 2010–2016 Statewide Election Composite, which produces a 47.92% statewide Democratic vote share.)

Legend:

- County Grouping Boundaries
- County Boundaries
- Computer–Simulated Senate Districts (Including frozen districts from the 2017 Senate Plan) Numbered from 1 to 50

Figure 14:
Senate Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Democratic-Favoring Districts in 2017 Senate Plan Versus 1,000 Simulated Plans
(Measured Using 2010–2016 Election Composite)



favorable to Democrats. In Appendix A, I present the projected number of Democratic seats across all of the Senate simulations using just the 2016 Attorney General election, which was a near-tied statewide election. Using the 2016 Attorney General election to measure district partisanship, the enacted 2017 Senate Plan contains 20 Democratic-favoring districts out of 50 total districts, while 99.9% of the computer-simulated plans contain 22 to 24 Democratic districts.

Uniform Swing Adjustments: I perform uniform swing calculations in the same way as I did earlier for the House simulations. In Figures U7 to U9, I compare the partisanship of the 2017 Senate Plan and the 1,000 computer-simulated plans in Senate Simulation Set 1 using various uniform swings. To create these Figures, I applied various alternative uniform swings to the 2010-2016 Statewide Election Composite, ranging from -6% to +6% (at intervals of 0.5%). Under each of these 25 uniform swing conditions, I calculate each Senate plan's number of Democratic-favoring Senate districts, as measured using the 2010-2016 Statewide Election Composite and adjusting for the uniform swing.

Figure U7 thus contains 25 rows, corresponding to these 25 different alternative uniform swings (e.g., +6%, +5.5%, +5.0%, etc.). As explained earlier, the 2010-2016 Statewide Election Composite produced an overall 47.92% Democratic vote share statewide. Therefore, a +0% uniform swing condition corresponds to a 47.92% statewide Democratic vote share, a +6% uniform swing corresponds to a 53.92% statewide Democratic vote share, and a -6% uniform swing corresponds to a 41.92% statewide Democratic vote share. The rows in Figure U7 are labeled with the statewide Democratic vote share that corresponds to the uniform swing applied in each row. The middle (13th from top) row in Figure U7 applies a +0% uniform swing, which corresponds to a 47.92% statewide Democratic vote share. Each row moving upward from this row depicts an additional +0.5% in the uniform swing applied, and each row moving downward depicts a decrease of 0.5% in the uniform swing applied. Therefore, the bottom row in figure U7 applies a -6% uniform swing, which corresponds to a 41.92% statewide Democratic vote share, and the top row applies a +6% uniform swing, which corresponds to a 53.92% statewide Democratic vote share.

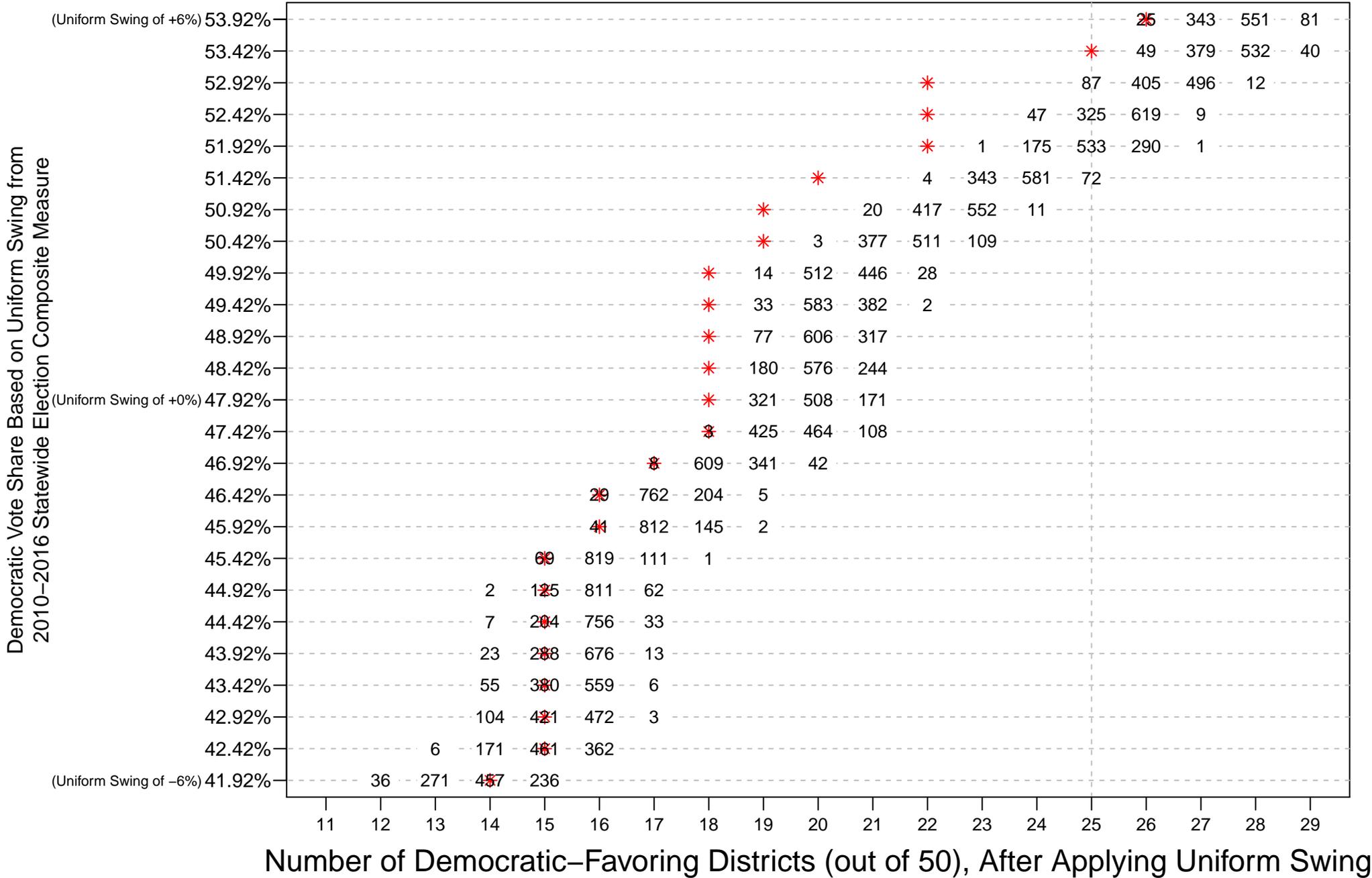
I applied the uniform swings in each row as follows: A uniform swing adjustment of +4.5%, for example, means that I calculated each district's Democratic vote share using the 2010-2016 Statewide Election Composite and added +4.5% to each district's vote share. I made

this same uniform swing adjustment for both the 2017 Senate Plan as well as for all 1,000 computer-simulated plans. I then identified the number of districts in each plan with over a 50% Democratic vote share, after accounting for the uniform swing adjustment.

Figure U7 displays these calculations under each of the 25 different alternative uniform swings. The top row of Figure U7, which applies a uniform swing of +6% (corresponding to a 53.92% statewide Democratic vote share), reports the number of Democratic-favoring districts in each of the 1,000 simulated plans, as measured using the 2010-2016 Statewide Election Composite with a +6% uniform swing. This row contains a series of numbers, corresponding to the horizontal axis, reporting the number of computer-simulated plans (out of 1,000) that contain a particular number of Democratic-favoring districts. Specifically, this top row reports 25 simulated plans containing 26 Democratic districts, 343 simulated plans containing 27 Democratic districts, 551 simulated plans containing 28 Democratic districts, and so on. Hence, the numbers in Figure U7 report the number of simulated plans that would contain a particular number of Democratic districts, as listed along the horizontal axis of the Figure. The red star in each row of Figure U7 denotes the number of Democratic districts for the 2017 Senate Plan under each uniform swing adjustment.

Figure U7 reveals the uniform swing conditions under which the computer-simulated plans would create 25 or more Democratic-favoring Senate districts. With a uniform swing of +4.0%, which corresponds to a 51.92% statewide Democratic vote share, 82.4% of the simulated plans in Senate Simulation Set 1 would create 25 or more Democratic-favoring districts. Meanwhile, under this same uniform swing condition, the 2017 Senate Plan would contain only 22 Democratic districts. Similarly, with a uniform swing of +4.5%, which corresponds to a 52.42% statewide Democratic vote share, 95.3% of the simulated plans in Senate Simulation Set 1 would create 25 or more Democratic-favoring districts, but the 2017 Senate Plan would again contain only 22 Democratic districts. Figure U8 displays the calculations of each plan's number of Democratic districts under a uniform swing of +4%, which corresponds to a 51.92% statewide Democratic vote share. Figure U9 displays the calculations of each plan's number of Democratic districts under a uniform swing of +4.5%, which corresponds to a 52.42% statewide Democratic vote share.

Figure U7: Number of Democratic Districts Under Alternative Uniform Swings in Senate Simulation Set 1 Plans



(Numbers in this figure report the number of simulated plans (out of 1,000) that would contain a particular number of Democratic districts (listed along the horizontal axis) under each uniform swing condition (listed in the left margin). Red stars denote calculations for the 2017 Senate Plan.)

**Figure U8:
 Number of Democratic Senate Districts Measured Using the 2010–2016 Election Composite
 With a +4% Uniform Swing, Corresponding to a 51.92% Statewide Democratic Vote Share
 (Senate Simulation Set 1)**

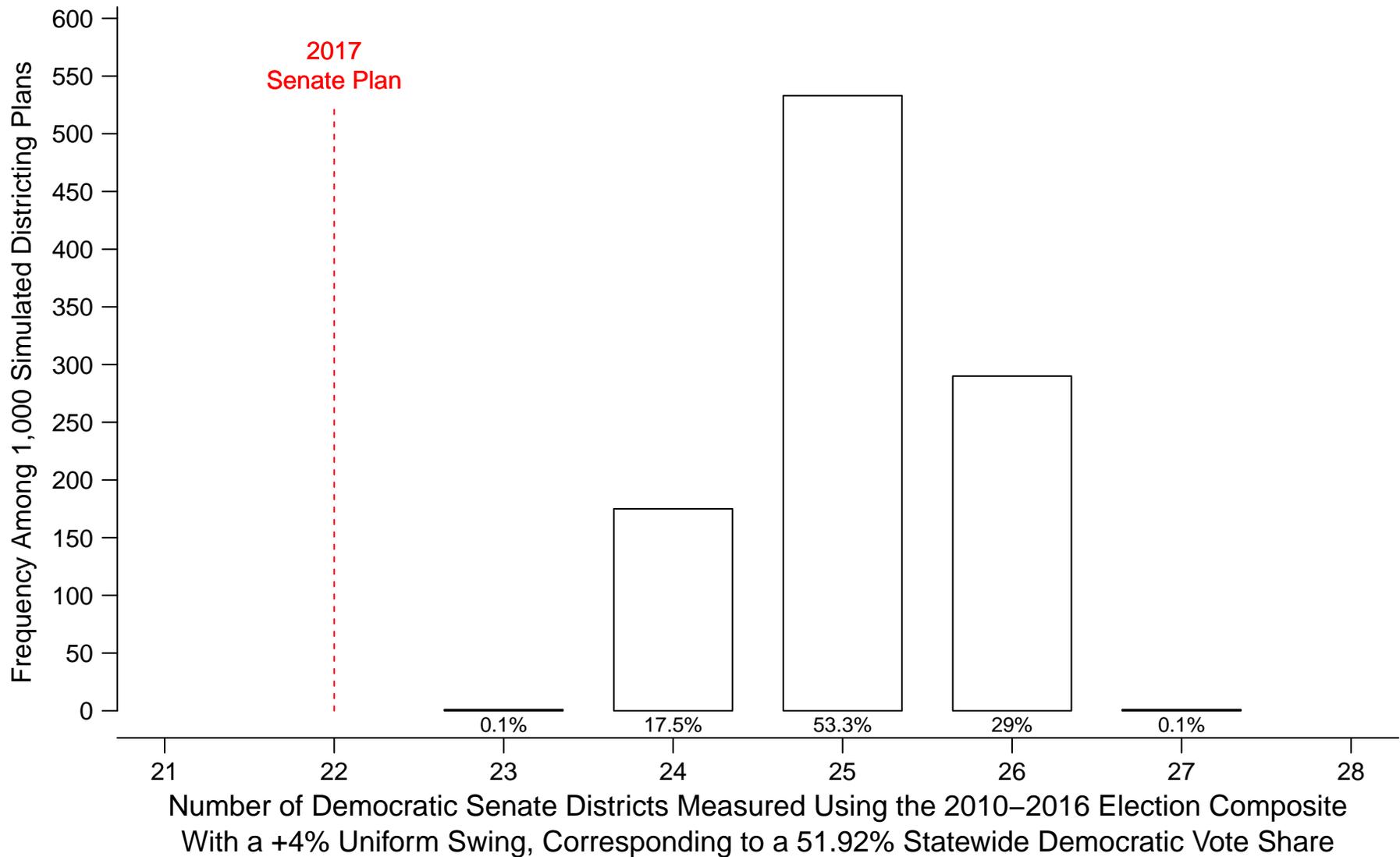
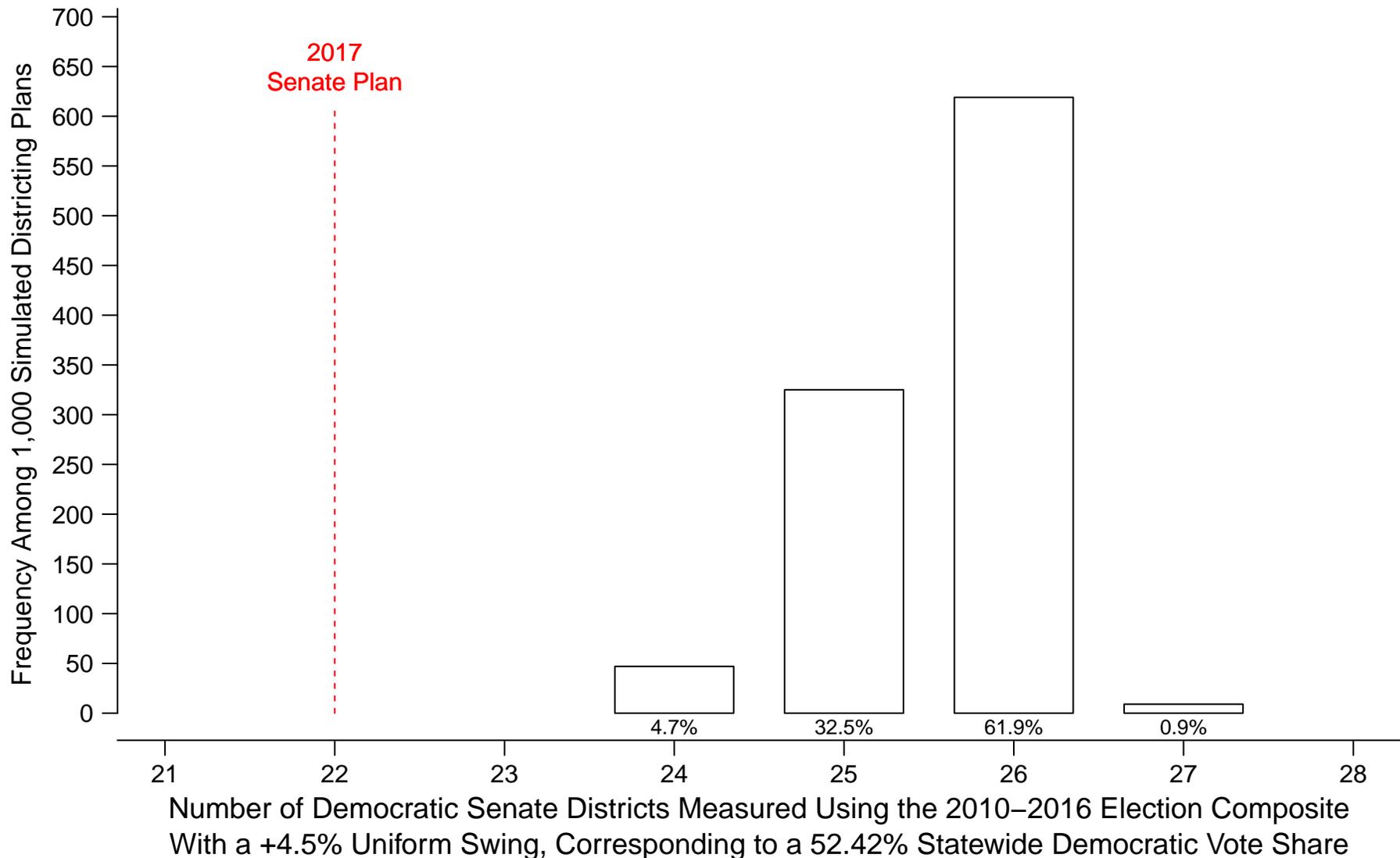


Figure U9:

Number of Democratic Senate Districts Measured Using the 2010–2016 Election Composite With a +4.5% Uniform Swing, Corresponding to a 52.42% Statewide Democratic Vote Share (Senate Simulation Set 1)

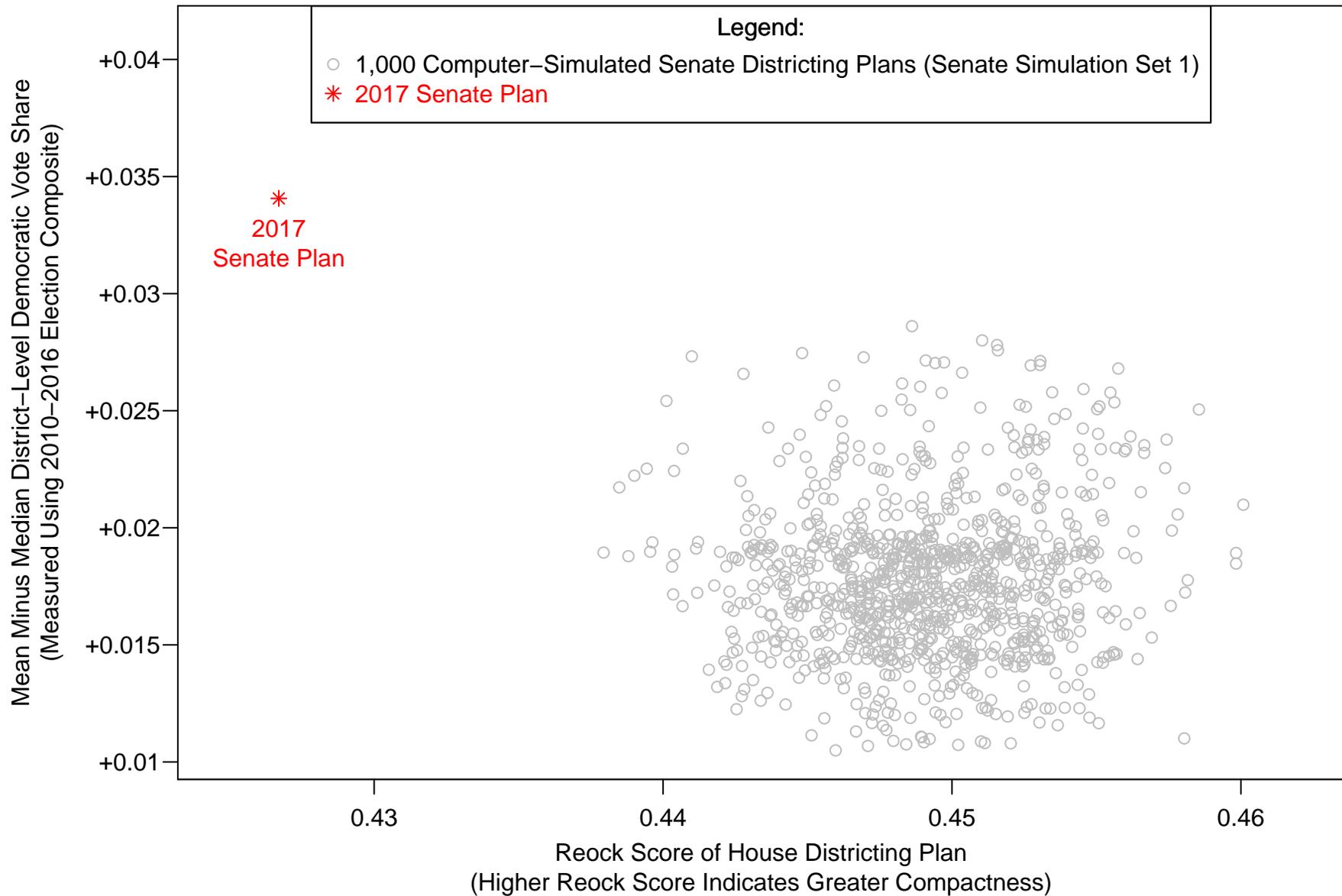


Mean-Median Difference: Analysis of the Mean-Median Difference confirms the partisan-outlying nature of the 2017 Senate Plan when compared to the computer-drawn plans in Senate Simulation Set 1. In Figure 15, the vertical axis measures the Mean-Median Difference of the 2017 Senate Plan and each simulated plan using the 2010-2016 Statewide Election Composite, while the horizontal axis measures the average Reock score of the districts within each plan, with higher Reock scores indicating more compact districts. In this Figure, each of the gray circles represents one of the 1,000 computer-simulated plans in Senate Simulation Set 1, while the red star represents the 2017 Senate Plan. Figure 15 illustrates that the 2017 Senate Plan's Mean-Median Difference is +3.4%, indicating that the median district is skewed significantly more Republican than the plan's average district. Figure 15 further illustrates that this difference is an extreme statistical outlier compared to the 1,000 simulations in Senate Simulation Set 1. Indeed, the 2017 Senate Plan's +3.4% Mean-Median Difference is an outcome never observed in these 1,000 simulated plans. The 1,000 simulated plans all exhibit Mean-Median Differences ranging from +1.0% to +2.9%. In fact, the middle 50% of these computer-simulated plans have Mean-Median Differences ranging from +1.5% to +1.9%, indicating a much smaller degree of skew in the median district than occurs in the 2017 Senate Plan.

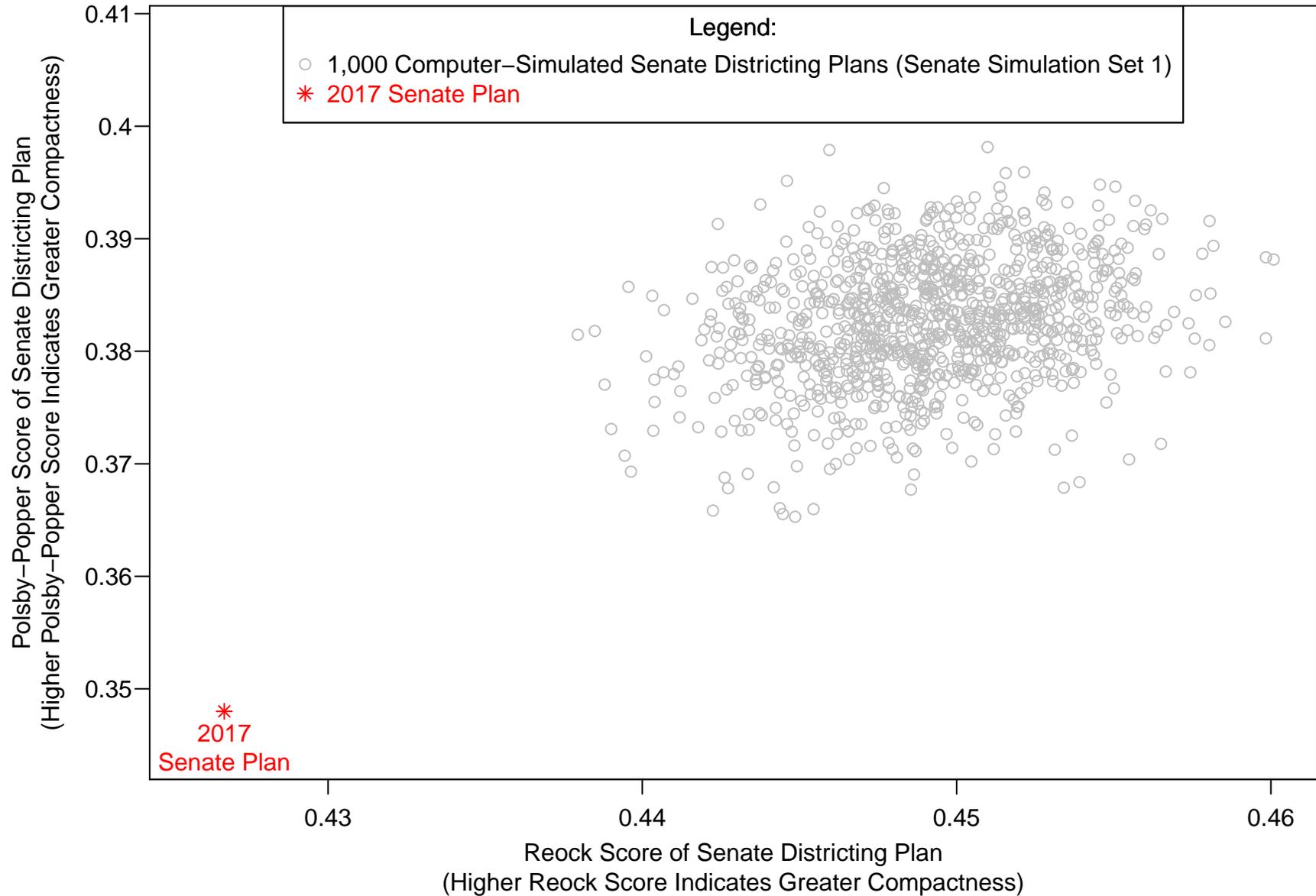
The fact that the 1,000 simulated plans in Figure 15 all produce a small, positive Mean-Median Difference indicates that voter geography may be modestly skewed in a manner that slightly benefits the Republicans in North Carolina Senate districting. This modest skew in the simulated districting plans may result partially from Democratic voters' tendency to cluster in large, urban areas of North Carolina. Additionally, the modest skew may partially result from the county groupings that the General Assembly created under the 2017 Senate Plan, as my simulation algorithm simply follows the same county grouping boundaries used in the enacted plan. But more importantly, the range of this natural skew, as shown in Figure 15, is always much smaller than the extreme +3.4% Mean-Median Difference observed in the 2017 Senate Plan. Hence, these results confirm the main finding that the 2017 Senate Plan creates an extreme partisan outcome that cannot be explained by North Carolina's voter geography or by the application of the non-partisan districting criteria listed in the 2017 Adopted Criteria.

Was the 2017 Senate Plan produced with reasonable efforts to draw compact districts? Figure 16 illustrates the compactness of the 1,000 simulated plans, compared against the compactness of the enacted 2017 Senate Plan. In this Figure, the horizontal axis depicts the

Figure 15:
Senate Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Comparison of 2017 Senate Plan to 1,000 Simulated Plans on Compactness and Mean-Median Difference



**Figure 16:
Senate Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Comparison of 2017 Senate Plan Versus 1,000 Simulated Plans on Compactness**



average Reock score of the districts within each plan, while the vertical axis depicts the average Polsby-Popper score. Higher Reock scores and higher Polsby-Popper scores both indicate greater geographic compactness. Each gray circle in this Figure represents one of the 1,000 simulated plans, while the red star denotes the enacted 2017 Senate Plan. Figure 16 illustrates that the 2017 Senate Plan is significantly less geographically compact than every single one of the simulated plans in Senate Simulation Set 1, whether measured by average Reock or average Polsby-Popper scores. The simulated plans contain Reock scores ranging from 0.438 to 0.460, while the 2017 Senate Plan produces a Reock score of only 0.427. Similarly, the simulated plans have Polsby-Popper scores ranging from 0.365 to 0.398, while the 2017 Senate Plan produces a Polsby-Popper score of only 0.348. Hence, it is clear that the 2017 Senate Plan was not drawn with an effort to create districts that are as geographically compact as reasonably possible.

Was the 2017 Senate Plan produced with reasonable efforts to pursue any of the other non-partisan districting criteria outlined in the 2017 Adopted Criteria? Once again, the computer simulations offer insight into the type and range of plans that would have emerged had reasonable efforts been made to adhere to the non-partisan portions of the 2017 Adopted Criteria. As detailed in Figure 17, the 2017 Senate Plan split far more municipalities than was reasonably necessary: The 1,000 computer-simulated plans split from 8 to 12 municipalities, while the 2017 Senate Plan splits 25 municipalities. Furthermore, as Figure 18 illustrates, the 2017 Senate Plan also split more VTDs than was reasonably necessary: The 1,000 computer-simulated plans split between 0 to 3 VTDs, while the 2017 Senate Plan split 5 VTDs. Hence, it is clear that the 2017 Senate Plan did not seek to split as few municipalities and VTDs as reasonably possible.

Why did the 2017 Senate Plan so significantly subordinate these non-partisan criteria of geographic compactness and minimizing VTD and municipality splits? The 2017 Senate Plan is entirely outside the range of the 1,000 simulated maps with respect to both the partisan distribution of seats (Figure 14 and 15) and geographic compactness (Figure 15 and 16), in addition to splitting far more municipalities (Figure 17) and VTDs (Figure 18) than would have occurred if the map-drawer had simply followed the non-partisan portions of the 2017 Adopted Criteria. Collectively, these findings suggest that the 2017 Senate Plan was drawn under a process in which a partisan goal – the skewing of districts in a pro-Republican direction and the creation of additional Republican districts – predominated over adherence to the non-partisan districting criteria described in the 2017 Adopted Criteria. The predominance of this extreme

partisan goal subordinated the non-partisan, traditional districting considerations of minimizing VTD splits, following municipal boundaries, and drawing geographically compact districts.

Figure 17:
Senate Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Split Municipalities in 2017 Senate Plan Versus 1,000 Simulated Plans

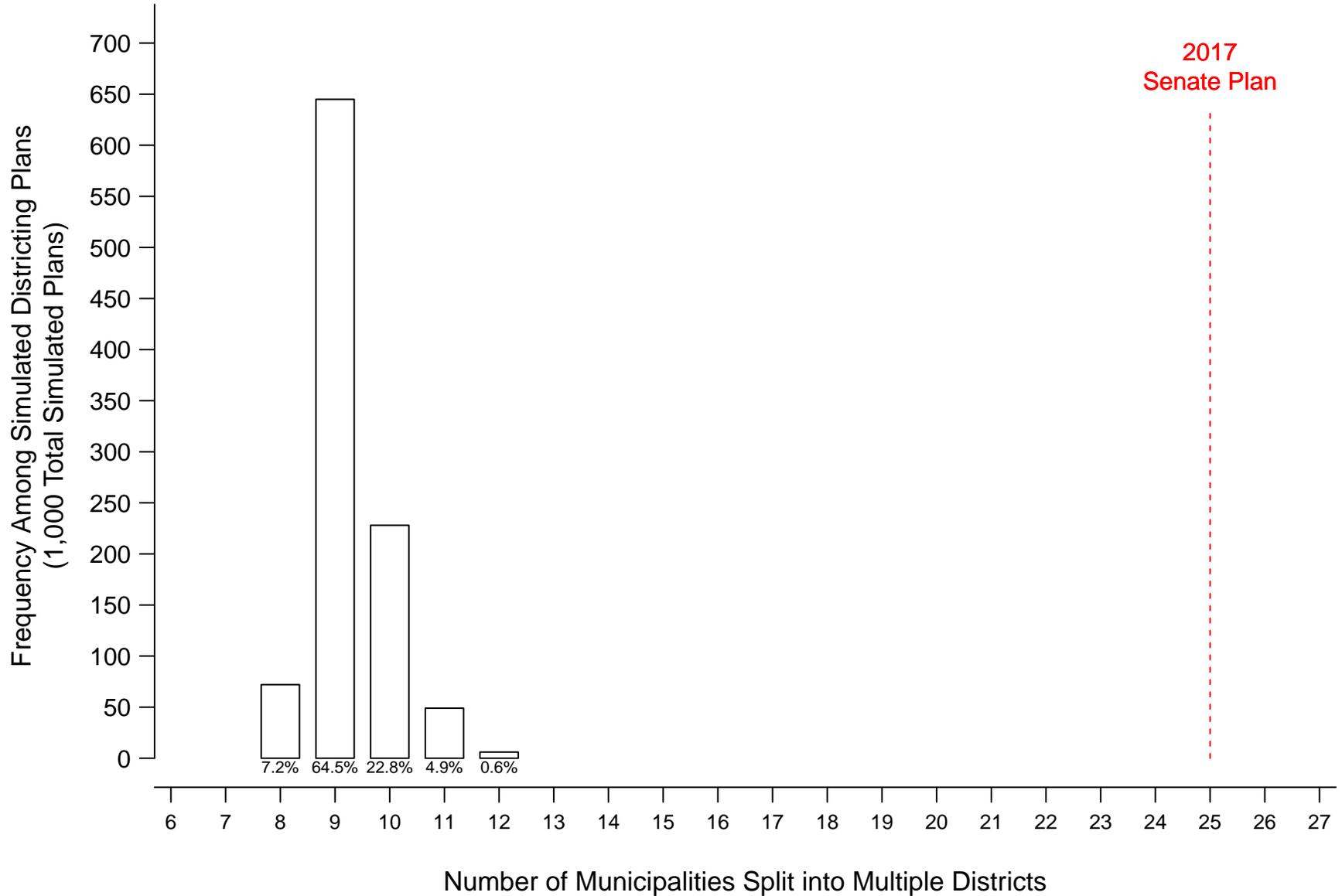
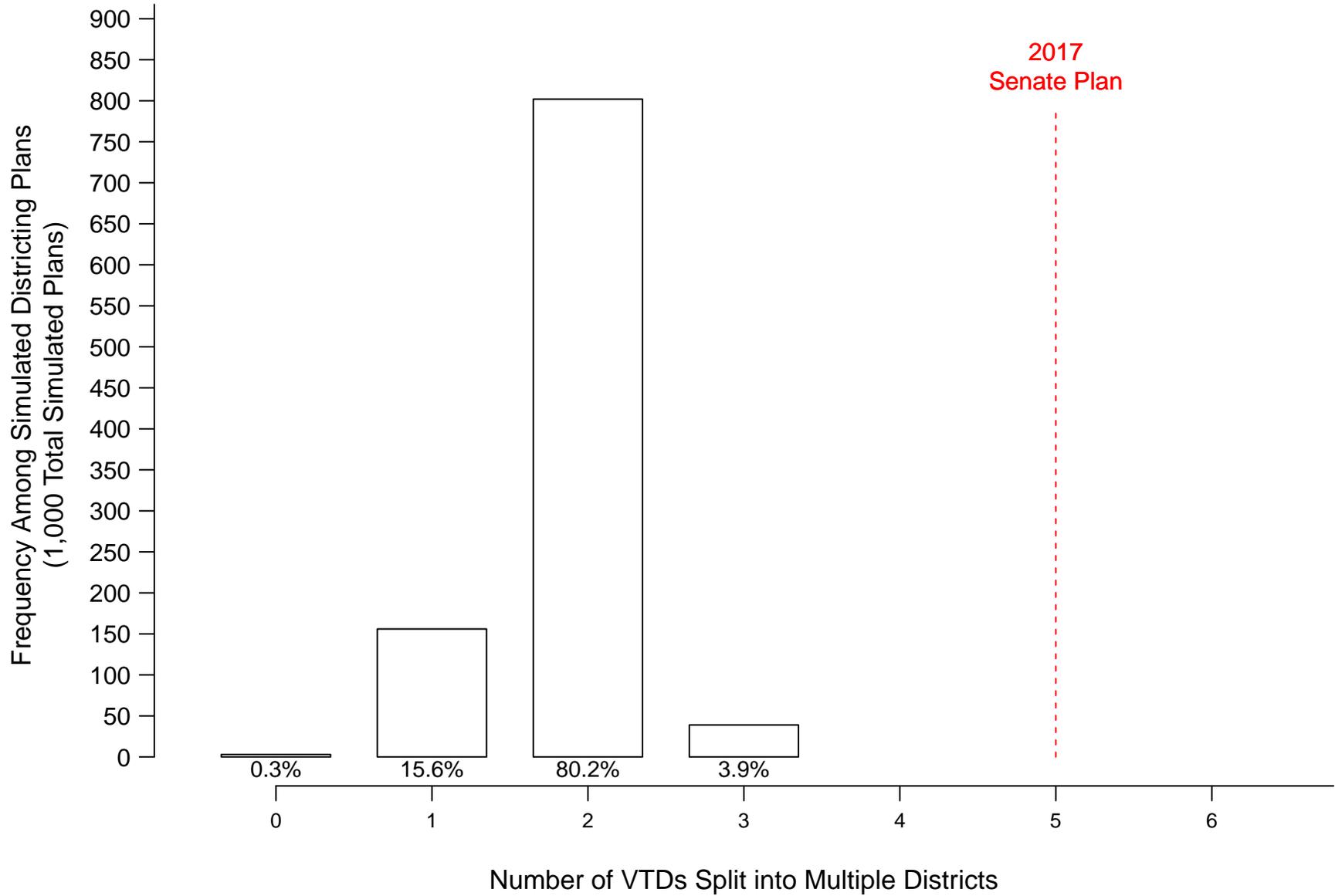


Figure 18:
Senate Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Split VTDs in 2017 Senate Plan Versus 1,000 Simulated Plans



Senate Simulation Set 2:

Following Traditional Districting Criteria While Protecting Incumbent Representatives

In producing Senate Simulation Set 1, the computer algorithm ignored any considerations regarding the protection of incumbent Senators or the pairing of incumbents within the same district. Just as I did with House Simulation Set 1, I initially ignored this portion of the 2017 Adopted Criteria because the protection of incumbent Senators during the redistricting process could cause indirect partisan consequences.

Among the 48 relevant incumbents holding office at the time of the original drawing of each of the current districts, 30 incumbents (or 64%) were Republican, while only 17 incumbents were Democrats. These incumbents were elected from previous versions of North Carolina's Senate districts. As this slate of incumbents was heavily Republican and was elected from previous versions of North Carolina's Senate districts, an attempt to protect all incumbents would, in general, encourage the drawing of a plan with districts somewhat similar to the previous districts from which the incumbents had been previously elected, thus indirectly distorting the partisan distribution of voters across districts. Hence, I conducted the first set of simulations (Senate Simulation Set 1) with no efforts at incumbency protection in order to analyze the range of plans that could emerge from strict adherence to the non-partisan portions of the 2017 Adopted Criteria.

Nevertheless, I also analyzed whether the significant Republican bias created by the enacted 2017 Senate Plan could have simply resulted from an effort to protect the incumbent members of North Carolina's Senate by not pairing two or more of them into the same district. I evaluated this possible explanation by conducting a second set of districting simulations (Senate Simulation Set 2) designed to intentionally protect exactly as many incumbents as is mathematically possible within each county grouping while otherwise adhering to the traditional districting criteria described earlier. Moreover, the computer algorithm was instructed to protect the very same incumbents that are protected under the 2017 Senate Plan's districts, meaning that my simulations did not double-bunk any incumbent who was not double-bunked under the enacted plan. I found that even a districting process that intentionally protects as many incumbents as is mathematically possible (while also protecting the specific incumbents protected by the 2017 Senate Plan) does not explain the extreme Republican advantage created by the 2017 Senate Plan.

I began by identifying the 2017 Senate Plan districts that were drawn in a manner that protected incumbent Senators from being paired with another incumbent. Specifically, I identified these protected incumbent Senators in the following three ways: First, within the Senate districts that were redrawn in 2017, I analyzed those Senate incumbents who were holding office when the General Assembly drew the 2017 Senate map. Second, Plaintiffs' counsel provided me with a list of those incumbents who had publicly announced their retirements before the enactment of the 2017 Senate Plan, and I removed these incumbents from consideration in my analysis. Furthermore, some Senate districts that were originally drawn in 2011 were not altered in the 2017 Senate Plan. Within these unaltered districts, I identified the incumbents holding office as of the 2011 redistricting process, since those were the incumbents whom the General Assembly would have been attempting to protect at the time those districts were drawn. In other words, for those Senate districts in the 2017 Senate Plan that were originally drawn in 2011 and not redrawn in 2017, I analyzed whether the incumbents holding office in 2011 were protected in those districts. In summary, the incumbents I considered in this analysis were only those Senators who were holding office (and had not announced retirement plans) when their respective districts were originally drawn, which was either in 2011 or in 2017.

For the Senate districts drawn in 2011 and unchanged in 2017, there were 17 incumbents meeting the criteria laid out above, and for the Senate districts redrawn in 2017, there were 31 incumbents meeting the criteria laid out above. Thus, in total, I identified 48 incumbent Senators relevant to my simulations in Simulation Set 2. Among these 48 total incumbent Senators, the relevant districts enacted in 2011 and 2017 protected 38 of the incumbents.

Having identified the 48 total relevant incumbents for the Senate districts, I then conducted a second, separate set of simulations. Senate Simulation Set 2 prioritizes the protection of incumbents while otherwise pursuing the same non-partisan districting criteria as Senate Simulation Set 1. Specifically, I programmed the computer algorithm to guarantee the protection of the mathematically maximum possible number of incumbents within each county grouping. Additionally, I also required that the algorithm produce districts that protect, at a minimum, the same set of incumbent Senators as the ones protected by the 2017 Senate Plan districts. In other words, the simulation algorithm guaranteed the protection of at least as many total incumbents as the 2017 Senate Plan protected, and the algorithm was also required to protect, at minimum, the same 38 incumbents that were protected in the 2017 Senate Plan.

This approach to protecting incumbents is an extremely conservative one because it not only maximizes the protection of incumbents, but it also defers to the enacted plans in terms of the precise set of incumbent Senators who are protected.

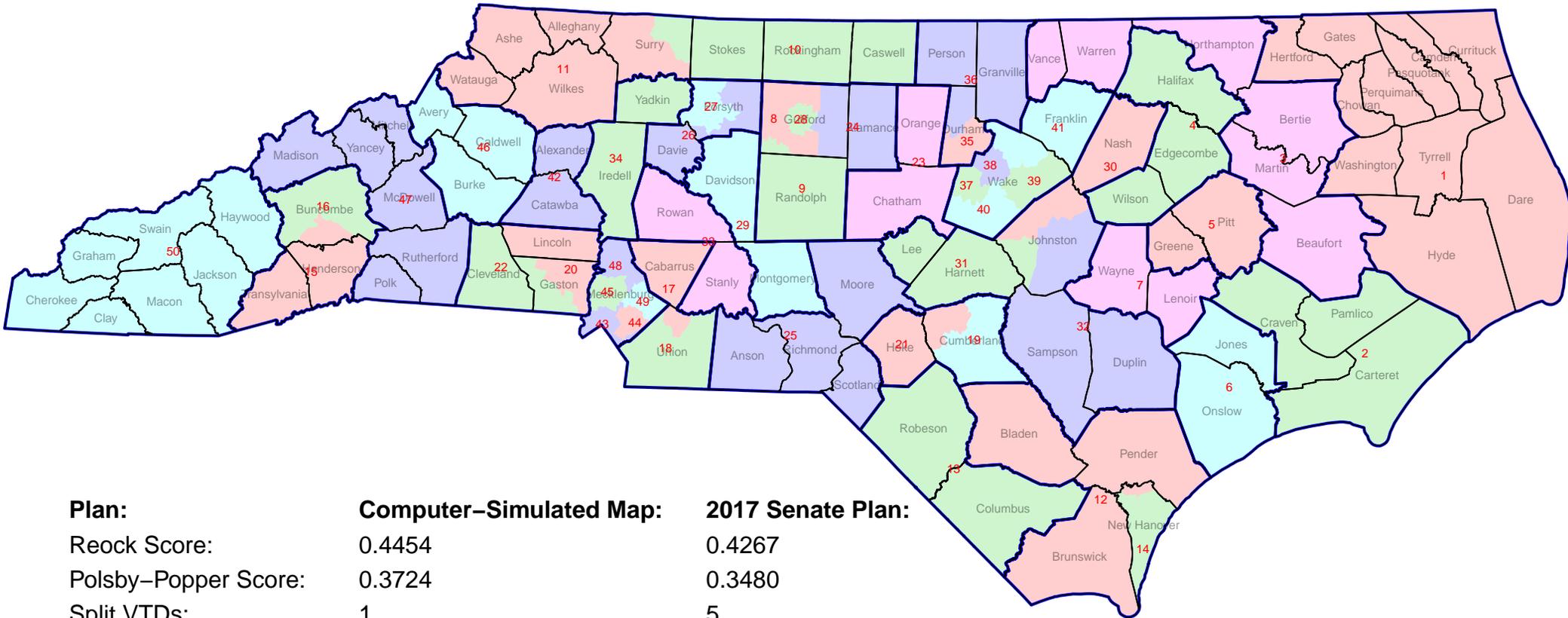
Aside from these two requirements, the computer algorithm gives no consideration to the partisanship of the incumbents that are protected or not protected under each simulated plan. And beyond this intentional protection of incumbents, Senate Simulation Set 2 otherwise prioritizes the same seven non-partisan traditional districting criteria followed in the first set of simulations while again ignoring any other political considerations beyond incumbent protection.

As an example of the maps produced by this algorithm, Figure 19 illustrates the final of the 1,000 simulated districting plans produced by the computer algorithm in Senate Simulation Set 2. Descriptions of the 1,000 simulated maps in Senate Simulation Set 2 appear in the third column of Table 6.

The protection of the maximum possible number of incumbents in Senate Simulation Set 2 was achieved without any increase in the number of county traversals, or split VTDs (Figure 24) and with only very slight decreases in the geographic compactness of the simulated districts (Figure 22) and a slight increase in split municipalities (Figure 23). Figure 22 illustrates that the 2017 Senate Plan is still significantly less compact than every single one of the 1,000 of the simulations in Senate Simulation Set 2, using both the Reock and Popper-Polsby measures of compactness. Figure 23 illustrates that the 2017 Senate Plan's splitting of 25 municipalities is significantly more than in every single one of the 1,000 simulated plans, which each split from 10 to 16 municipalities. Figure 24 illustrates that the 2017 Senate Plan's splitting of 5 VTDs is still more than in every single one of the 1,000 simulated plans, which each split from 0 to 3 VTDs. Altogether, these simulation results illustrate that the 2017 Adopted Criteria criterion of not pairing multiple incumbents can be achieved without significantly subordinating any of the non-partisan traditional districting criteria listed in the 2017 Adopted Criteria. The 2017 Senate Plan, however, clearly subordinated the non-partisan districting criteria of geographic compactness, avoiding VTD splits, and avoiding municipality splits.

Does the protection of Senate incumbents make the 2017 Senate Plan's Republican partisan bias a plausible outcome that could have emerged from a redistricting process adhering to non-partisan criteria? Figure 20 illustrates the distribution of partisan seats across the 1,000 simulated Senate plans, with partisanship measured using the 2010-2016 Statewide Election

**Figure 19:
Example of a Computer–Simulated Senate Map
From Senate Simulation Set 2 (Following Non–Partisan Redistricting Criteria and Protecting Incumbents)**



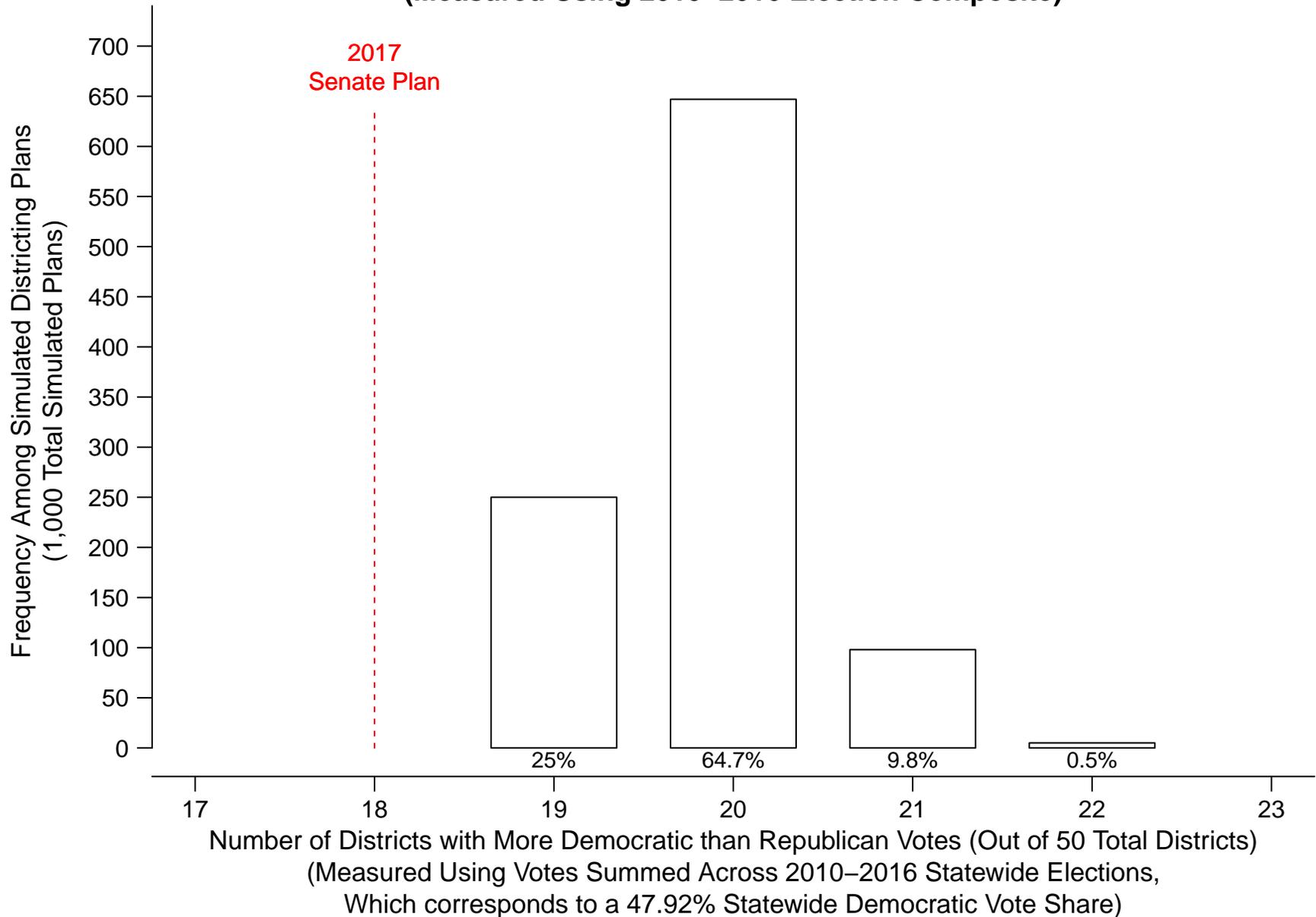
Plan:	Computer–Simulated Map:	2017 Senate Plan:
Reock Score:	0.4454	0.4267
Polsby–Popper Score:	0.3724	0.3480
Split VTDs:	1	5
Split Municipalities:	13	25
Mean–Median Difference:	+1.98%	+3.4%
Democratic Districts:	20	18

(District partisanship is measured using the 2010–2016 Statewide Election Composite, which produces a 47.92% statewide Democratic vote share.)

Legend:

- County Grouping Boundaries
- County Boundaries
- Computer–Simulated Senate Districts (Including frozen districts from the 2017 Senate Plan) Numbered from 1 to 50

**Figure 20:
Senate Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Protecting Incumbents):
Democratic-Favoring Districts in Enacted Senate Plan Versus 1,000 Simulated Plans
(Measured Using 2010–2016 Election Composite)**



composite. This Figure illustrates that the partisan distribution of seats in plans under Senate Simulation Set 2 is nearly identical to the partisan distribution of Senate Simulation Set 1, which ignored incumbency protection. When the maximum possible number of incumbents is protected, the simulation algorithm still continues to produce plans that range from 19 to 22 Democratic districts, as measured by the 2010-2016 Statewide Election composite. The 2017 Senate Plan's creation of only 18 Democratic districts is an outcome never achieved in Senate Simulation Set 2. Nor is the 2017 Senate Plan's creation of a +3.4% Mean-Median Difference an outcome ever observed in a single one of these 1,000 simulations (Figure 21). Finally, Figures U10, U11, and U12 also perform the same uniform swing calculations as presented earlier for Senate Simulation Set 1; these uniform swing calculations confirm that under uniform swings that would allow Democrats to win 25 or more Senate districts in the computer-simulated plans, the 2017 Senate Plan would contain significantly fewer than 25 Democratic districts.

Hence, we are able to conclude with extremely high statistical certainty that even the strictest adherence to the 2017 Adopted Criteria's mandate of protecting incumbents, combined with adherence to the other non-partisan portions of the 2017 Adopted Criteria, does not cause or explain the extreme degree of Republican advantage exhibited by the 2017 Senate Plan. Instead, the 2017 Senate Plan was drawn under a process in which a partisan goal – the skewing of districts in a pro-Republican direction and the creation of additional Republican districts – predominated over adherence to the non-partisan districting criteria described in the 2017 Adopted Criteria.

Figure 21:
Senate Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Protecting Incumbents):
Comparison of 2017 Senate Plan Versus 1,000 Simulated Plans on Compactness and Mean-Median Difference

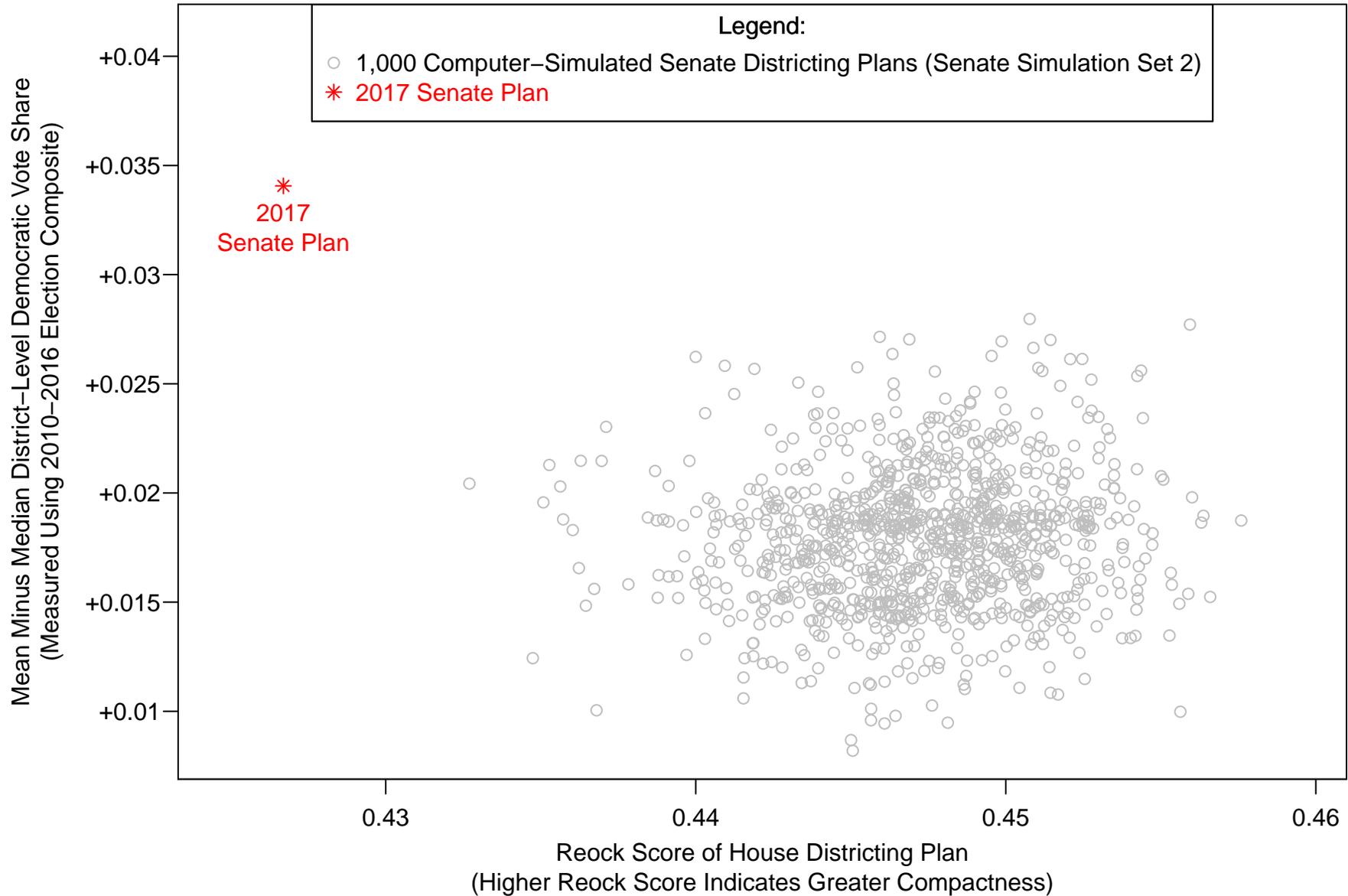


Figure 22:
Senate Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Protecting Incumbents):
Comparison of Enacted Plan Versus 1,000 Simulated Plans on Compactness

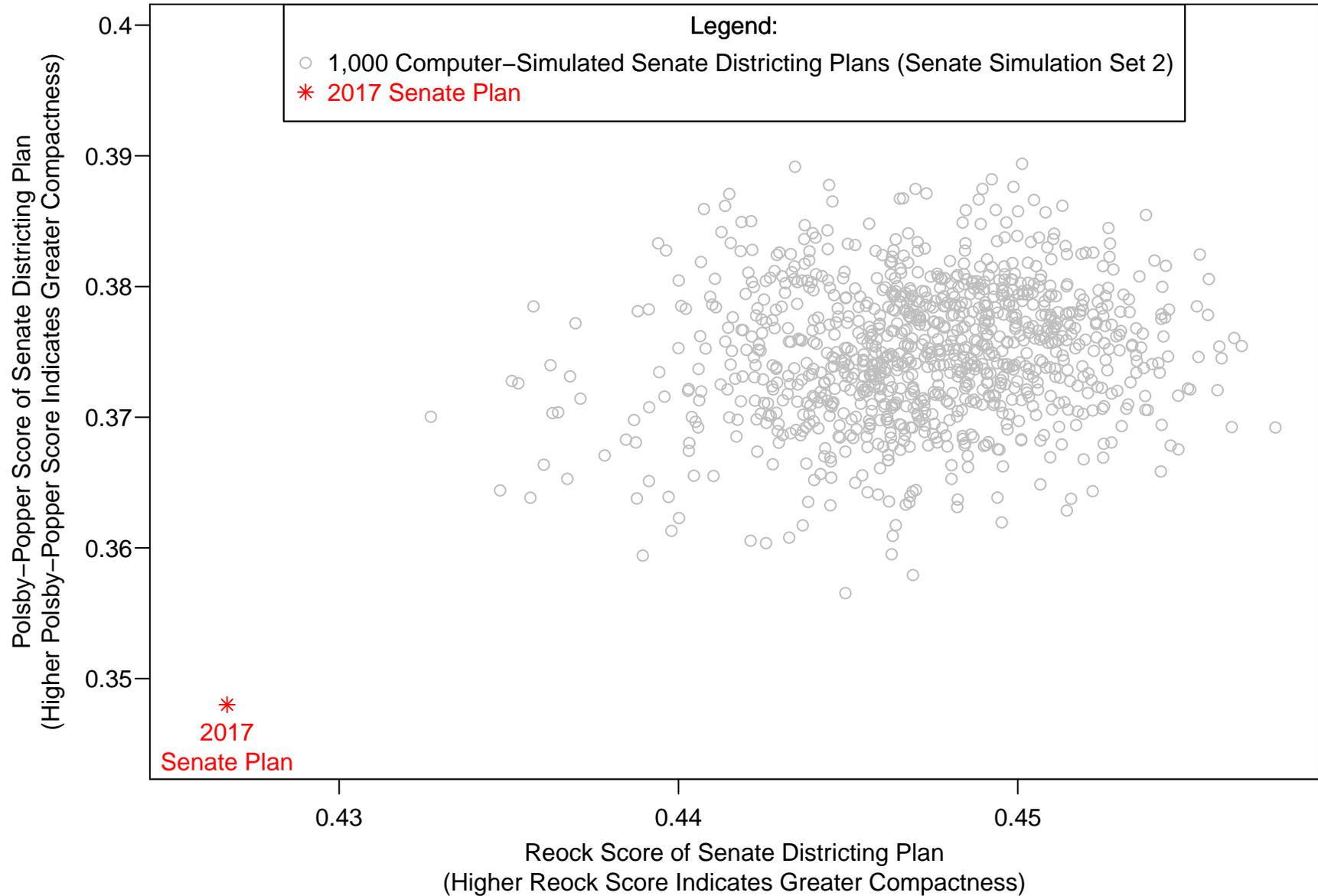


Figure 23:
Senate Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Protecting Incumbents):
Split Municipalities in Enacted Plan Versus 1,000 Simulated Plans

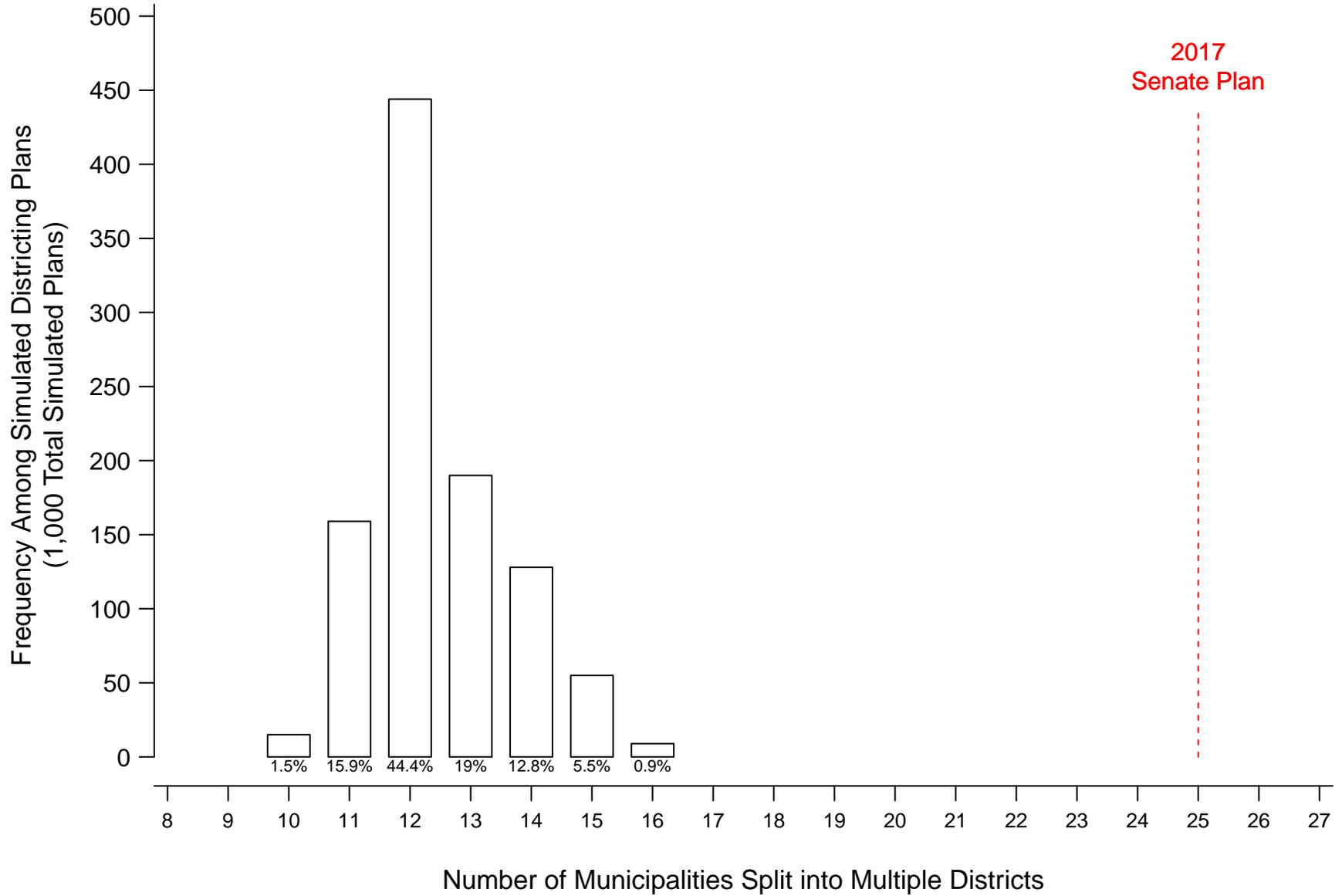


Figure 24:
Senate Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Protecting Incumbents):
Split VTDs in Enacted Plan Versus 1,000 Simulated Plans

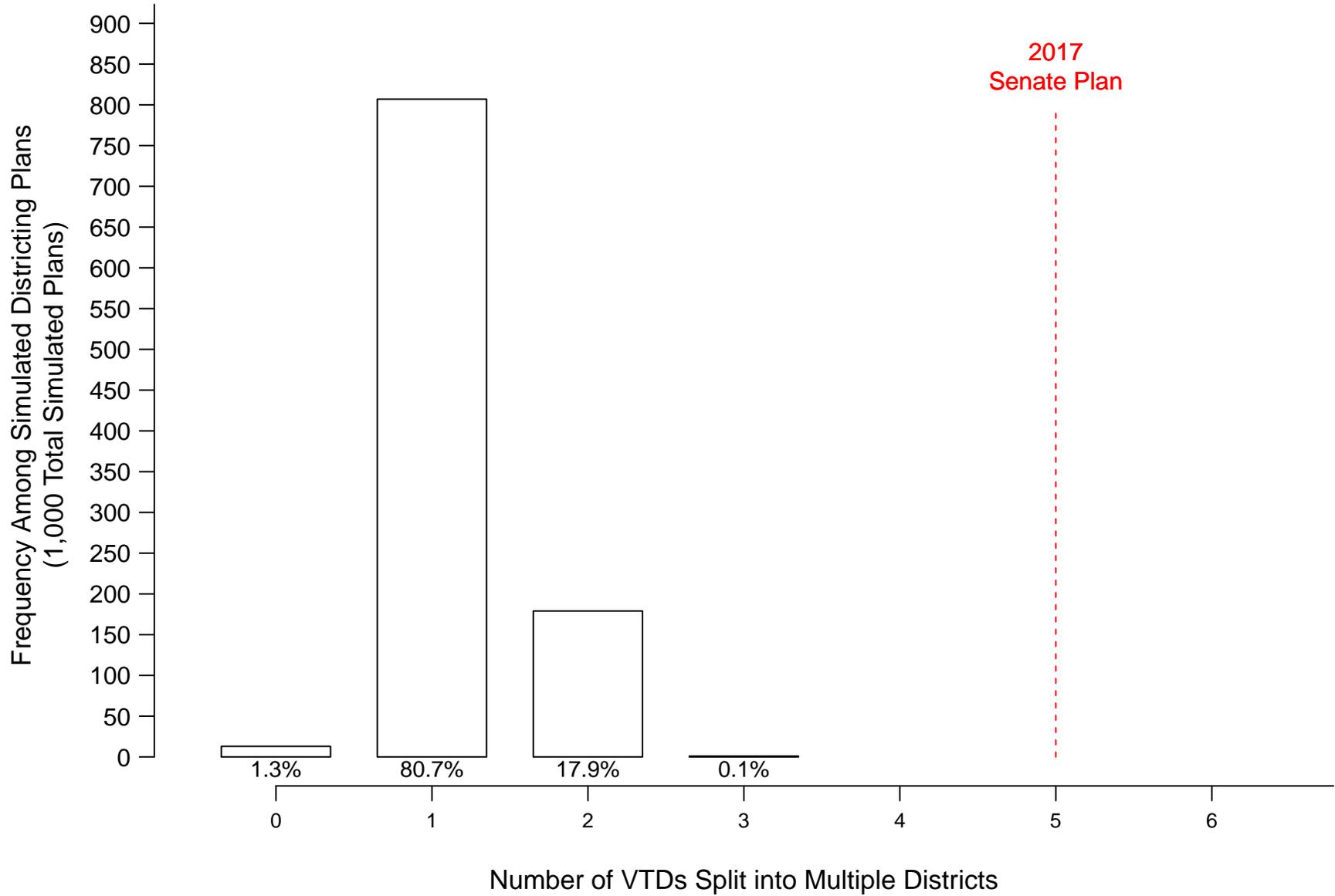
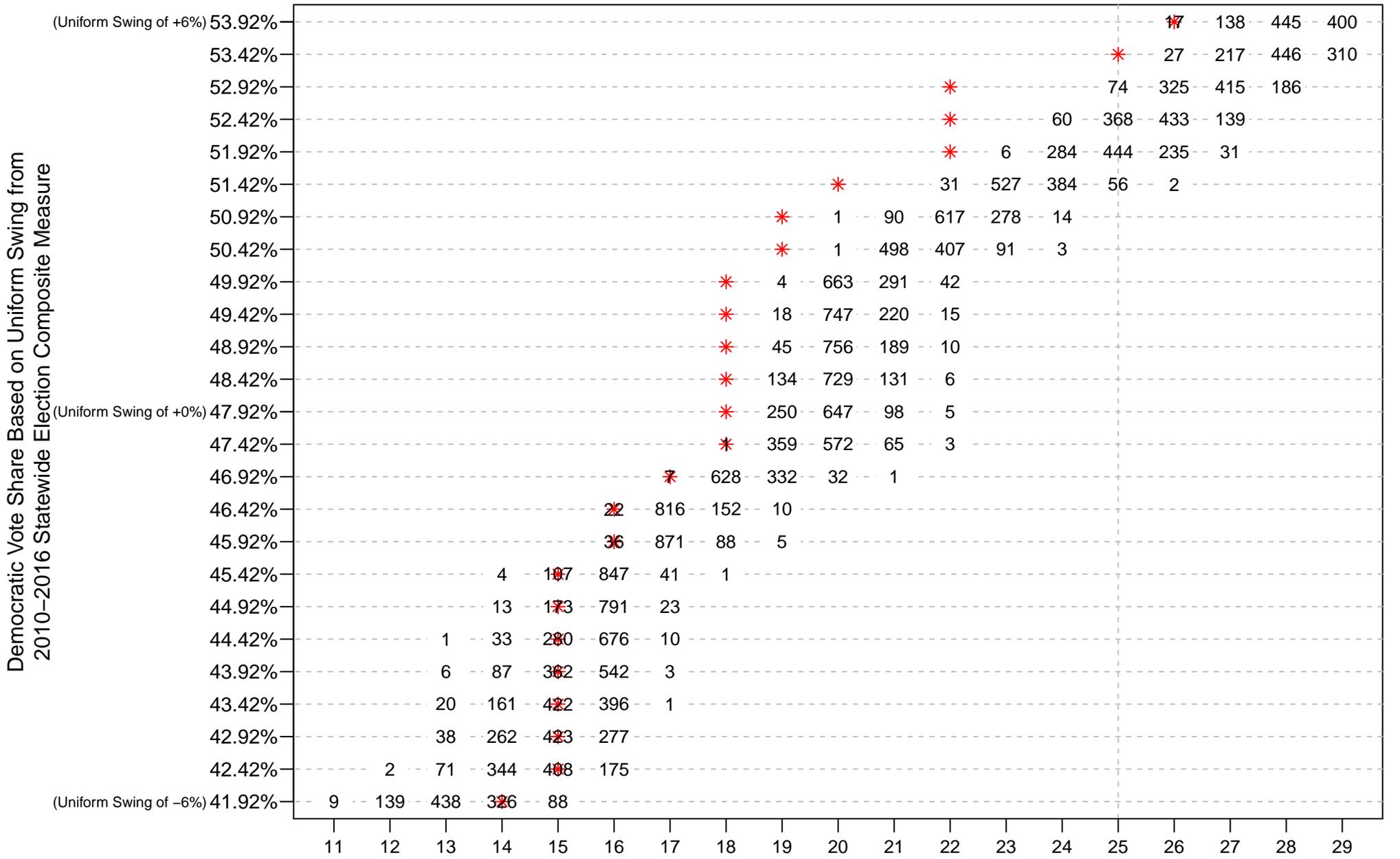


Figure U10: Number of Democratic Districts Under Alternative Uniform Swings in Senate Simulation Set 2 Plans



Number of Democratic-Favoring Districts (out of 50), After Applying Uniform Swing

(Numbers in this figure report the number of simulated plans (out of 1,000) that would contain a particular number of Democratic districts (listed along the horizontal axis) under each uniform swing condition (listed in the left margin). Red stars denote calculations for the 2017 Senate Plan.)

Figure U11:

Number of Democratic Senate Districts Measured Using the 2010–2016 Election Composite With a +4% Uniform Swing, Corresponding to a 51.92% Statewide Democratic Vote Share (Senate Simulation Set 2)

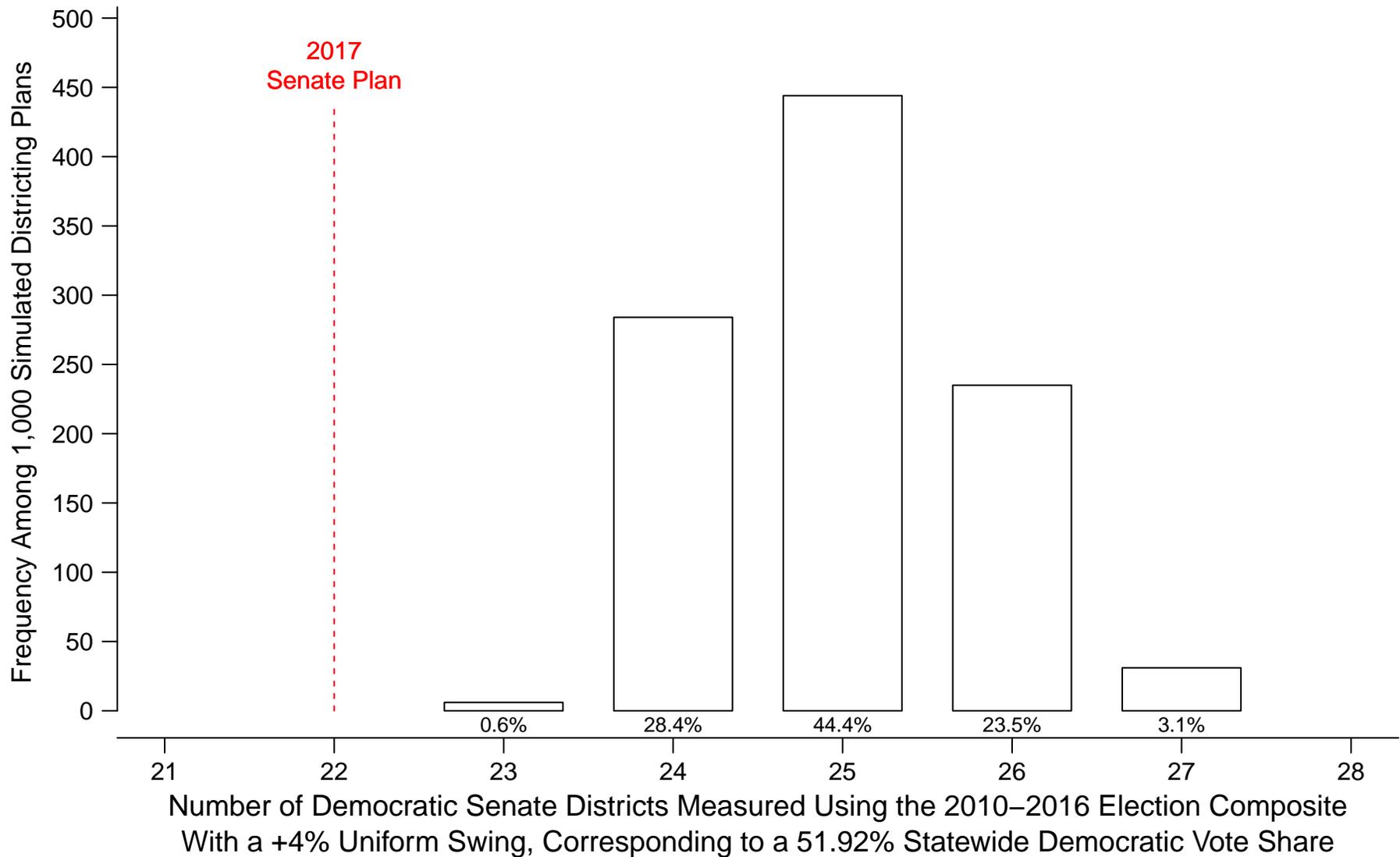
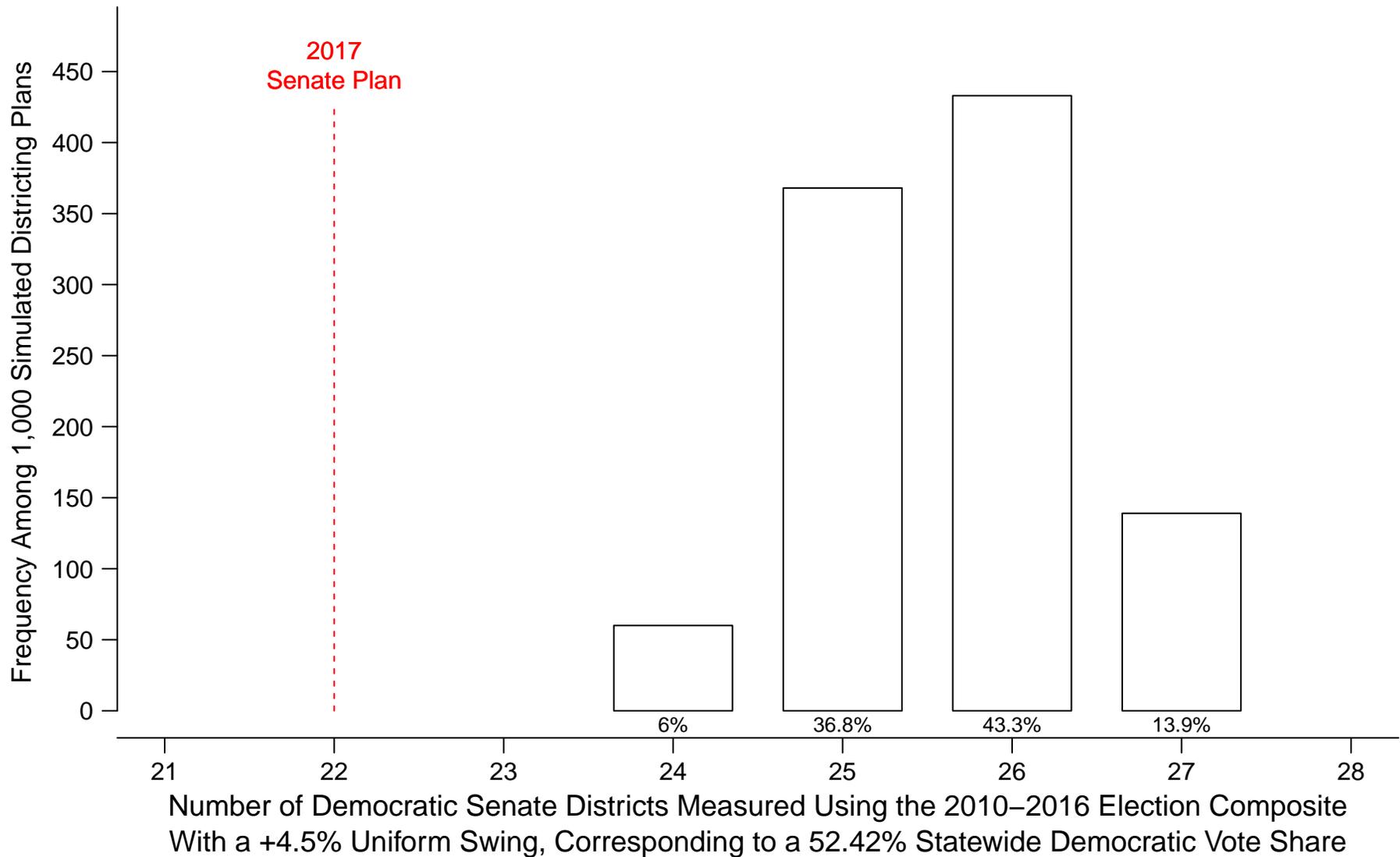


Figure U12:

Number of Democratic Senate Districts Measured Using the 2010–2016 Election Composite With a +4.5% Uniform Swing, Corresponding to a 52.42% Statewide Democratic Vote Share (Senate Simulation Set 2)



County Grouping-by-Grouping Analysis of the 2017 House Plan:

In addition to the plan-wide analysis described earlier, I also evaluated the extent to which partisan intent predominated in the drawing of individual county groupings in the 2017 House Plan. Specifically, I conducted an analysis of selected county groupings in the enacted plan using all of the computer-simulated House plans produced for this report. Using the two sets of 1,000 simulated House plans described earlier in this report (House Simulation Set 1 and Set 2), I compared the 2017 House Plan's version of districts within each county grouping to the entire distribution of computer-simulated districts in that same grouping. These comparisons allowed me to identify individual groupings in the 2017 House Plan that are partisan outliers compared to different versions of that grouping that emerged under the computer simulations. Within each county grouping, I compare the 2017 House Plan to the computer-simulated House plans using the following two approaches:

- 1) Within each county grouping, I directly compare the partisan distribution of districts in that grouping in the 2017 House Plan to the partisan distribution of districts in that grouping in each computer-simulated plan; and
- 2) Within each county grouping, I consider all of the 2017 House Plan districts in the grouping that are Republican-leaning (above 50% Republican vote share), and I identify the most minimally Republican-leaning of these enacted districts. For both the 2017 House Plan and each of the computer-simulated plans, I then compare the number of districts within the grouping that are at least as Republican-leaning as the most minimally Republican-leaning district within that grouping in the 2017 House Plan.

Comparing the Partisan Distribution of Districts in the Enacted and Simulated Plans:

Within each county grouping, I directly compare the partisan distribution of districts in the 2017 House Plan to the partisan distribution of districts in each computer-simulated plan. I first order the 2017 House Plan's districts within the county grouping from the most to the least-Democratic district, as measured by Democratic vote share using the 2010-2016 Statewide Election Composite. Next, I analyze each simulated plan from the set of 1,000 simulations and similarly order the simulated plan's districts within the same county grouping from the most to the least-Democratic district. I then directly compare the most-Democratic 2017 House Plan district within the county grouping to the most-Democratic simulated district within the same

grouping from each of the 1,000 computer-simulated plans. In other words, I compare one district from the 2017 House Plan to 1,000 computer-simulated districts, and I compare these districts with respect to their Democratic vote share. I then directly compare the second-most-Democratic district in the county grouping from the enacted plan to the second-most-Democratic district within the same grouping from each of the 1,000 simulated plans. I conduct the same comparison for each district in the 2017 House Plan within the grouping, comparing the enacted district to its computer-simulated counterparts from each of the 1,000 simulated plans.

Figure 27 provides a visual illustration of this analysis for the 2017 House Plan's county grouping that contains Columbus, Pender, and Robeson Counties. This county grouping contains three districts in the 2017 House Plan, so Figure 27 contains three separate rows. The top row of this Figure directly compares the partisanship of the most-Democratic 2017 House Plan district within the county grouping to the partisanship of the most-Democratic district within the same county grouping from each of the 1,000 simulated plans in House Simulation Set 1. The two percentages (in parentheses) in the right margin of this Figure report the percentage of these 1,000 simulated districts that are less Democratic than and more Democratic than the enacted plan district. Similarly, the second row of this Figure compares the second-most-Democratic district within the grouping from each plan, and the third row compares the third-most-Democratic district within the grouping from each plan. In each row of this Figure, the 2017 House Plan's district is depicted with a red star and labeled in red with its district number (e.g., HD-47); meanwhile, the 1,000 computer-simulated districts are depicted with gray circles.

As the top row of Figure 27 illustrates, the most-Democratic district in the 2017 House Plan (HD-47) is more heavily Democratic than all 1,000 of the most-Democratic districts within this grouping from each of the 1,000 computer-simulated plans. This calculation is also numerically reported in the right margin of the Figure. HD-47 is at least five percentage points more heavily Democratic than the most heavily Democratic district in the Columbus-Pender-Robeson County grouping in nearly all of the 1,000 plans in House Simulation Set 1. The vast majority of the computer-simulated counterpart districts would have been much more moderate in terms of partisanship: HD-47 exhibits a Democratic vote share of 59.65%, while all of the most-Democratic computer-simulated districts in this grouping would have exhibited a lower Democratic vote share, and over 96% of these simulated districts had a Democratic vote share between 52.3% to 55%. Therefore, I identify HD-47 as a partisan outlier when compared to its

1,000 computer-simulated counterparts, using a standard threshold test of 95% for statistical significance.

I use this same methodology to analyze each 2017 House Plan district within different county groupings. Figures 25 to 40 illustrate my grouping-by-grouping analysis for different county groupings using House Simulation Set 1 as a baseline for comparison and for identifying partisan outliers. Similarly, Figures 41 to 56 provide grouping-by-grouping analysis for the 2017 House Plan districts using House Simulation Set 2 as a baseline for comparison and for identifying partisan outliers. For county groupings containing districts that were originally drawn in 2011 and remained unchanged in the 2017 redistricting process, I used the 2004-2010 Statewide Election Composite to measure district partisanship in these Figures, since the 2004-2010 statewide elections represent the elections data available to and used by the General Assembly during the 2011 redistricting process.

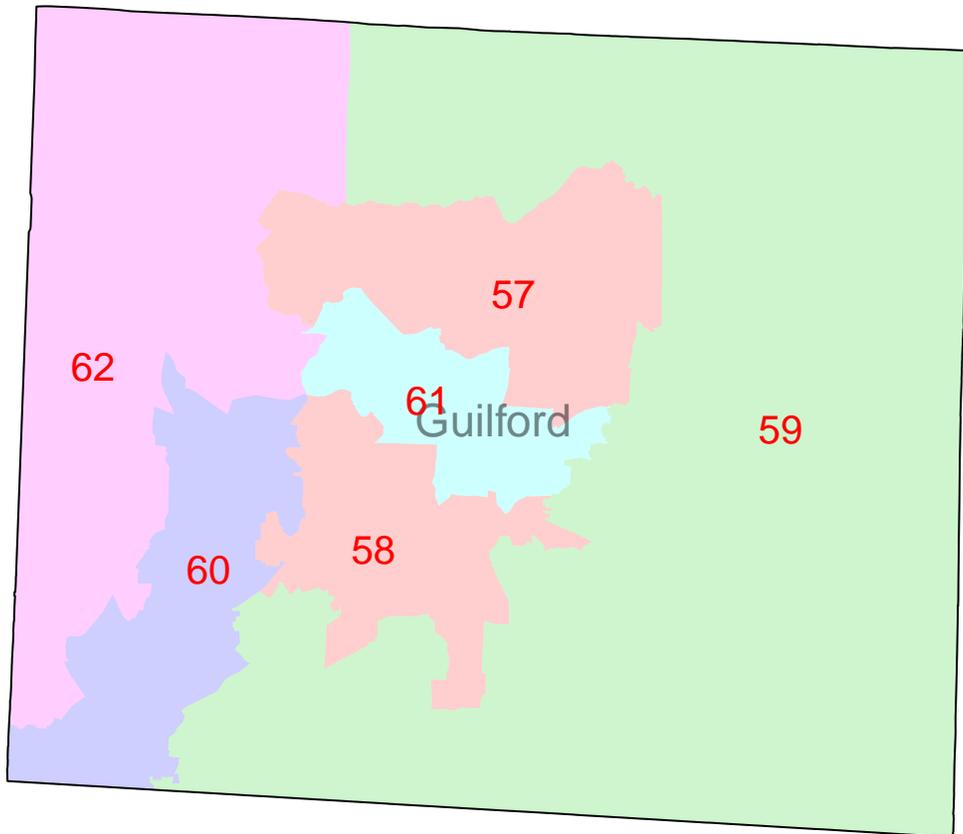
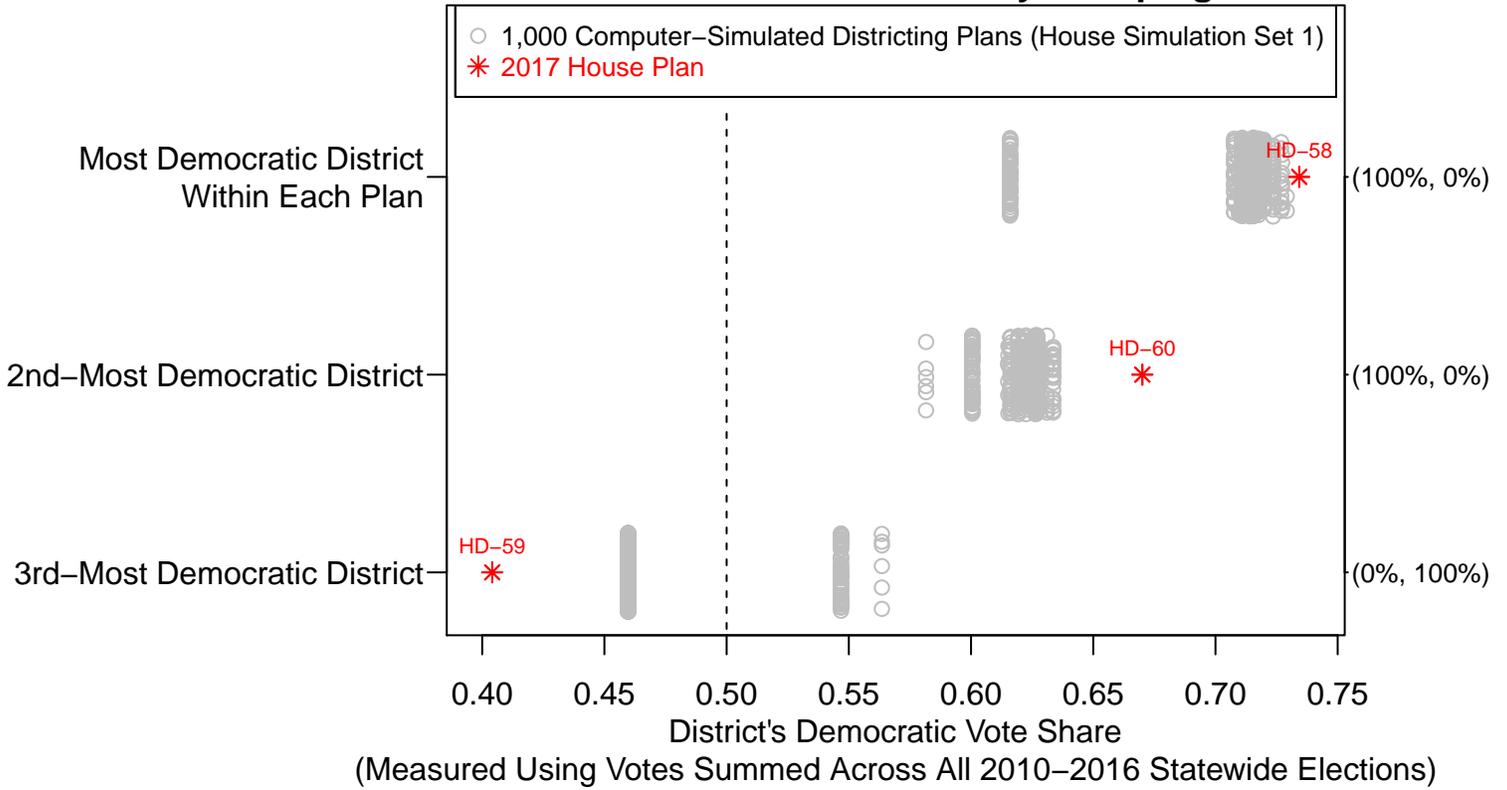
Finally, in the Guilford County grouping (whose results appear in Figures 25 and 41), which contains six total districts, note that three of the 2017 House Plan districts within Guilford County were materially redrawn by Special Master Nathaniel Persily and are frozen in all simulated plans in House Simulation Set 1 and Set 2. Therefore, these Special Master districts are not included in my analysis of the Guilford County grouping. Instead, Figures 25 and 41 show results only for the three other districts that are not frozen across all simulated plans (HD-58, HD-59, and HD-60). Hence, these two Figures contain only three rows, rather than six.

Overall, using this grouping-by-grouping comparison methodology, I found that the 2017 House plan contains partisan outlier districts within the following 15 House county groupings:

1. The Alamance County grouping (Figures 35 and 51).
2. The Anson-Union County grouping (Figures 36 and 52).
3. The Brunswick-New Hanover County grouping (Figures 37 and 53).
4. The Buncombe County grouping (Figures 38 and 54).
5. The Cabarrus-Davie-Montgomery-Richmond-Rowan-Stanly County grouping (Figures 26 and 42).
6. The Cleveland-Gaston County grouping (Figures 39 and 55).
7. The Columbus-Pender- Robeson County grouping (Figures 27 and 43).
8. The Cumberland County grouping (Figures 28 and 44).
9. The Duplin-Onslow County grouping (Figures 40 and 56).

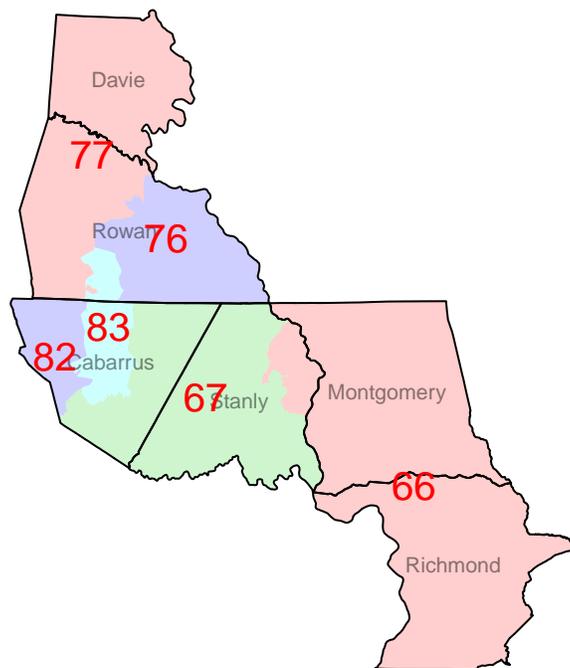
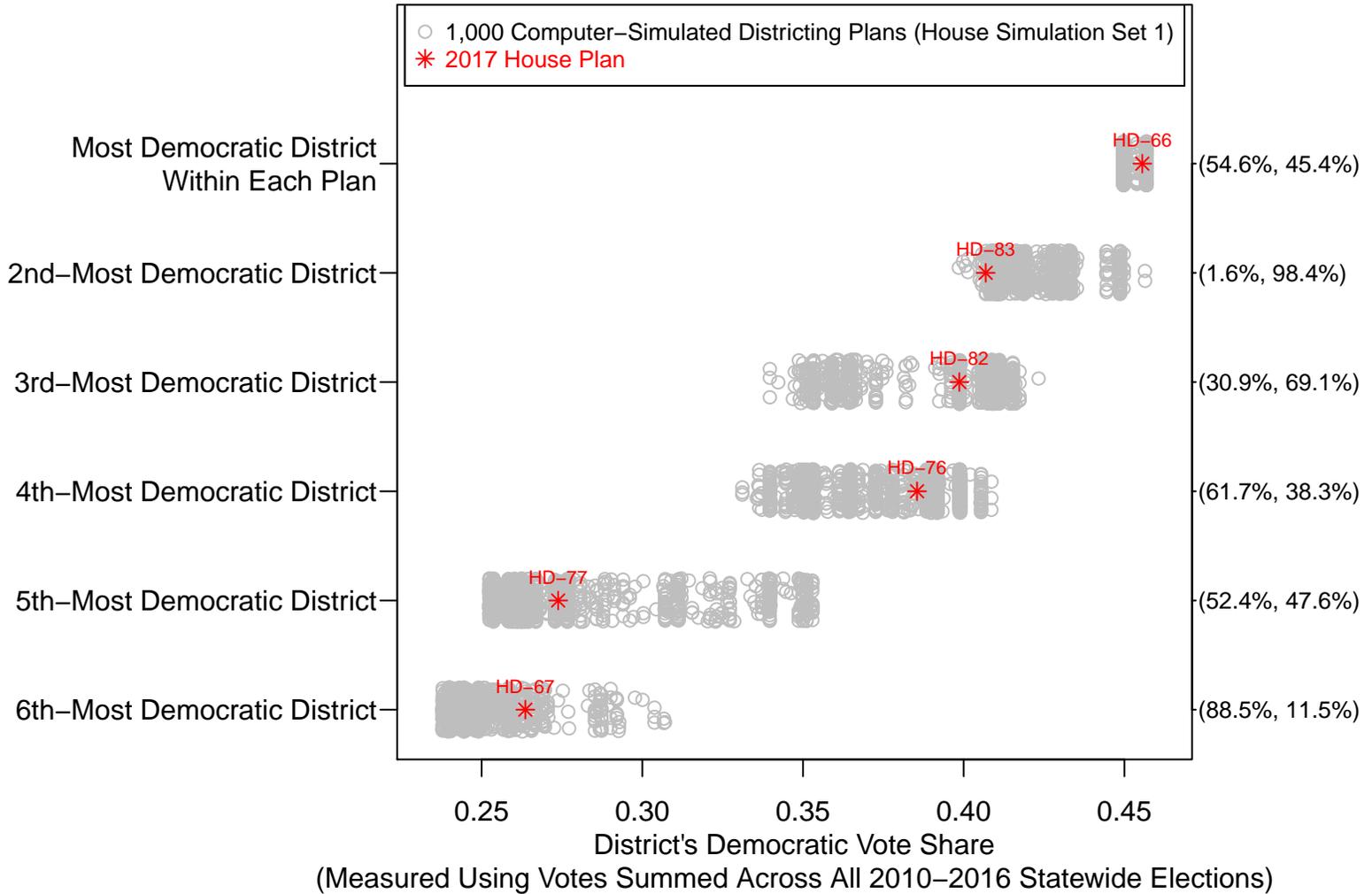
10. The Forsyth-Yadkin County grouping (Figures 29 and 45).
11. The Franklin-Nash County grouping (Figures 30 and 46).
12. The Guilford County grouping (Figures 25 and 41).
13. The Lenoir-Pitt County grouping (Figures 32 and 48).
14. The Mecklenburg County grouping (Figures 33 and 49).
15. The Wake County grouping (Figures 34 and 50).

**Figure 25: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Guilford County Grouping**



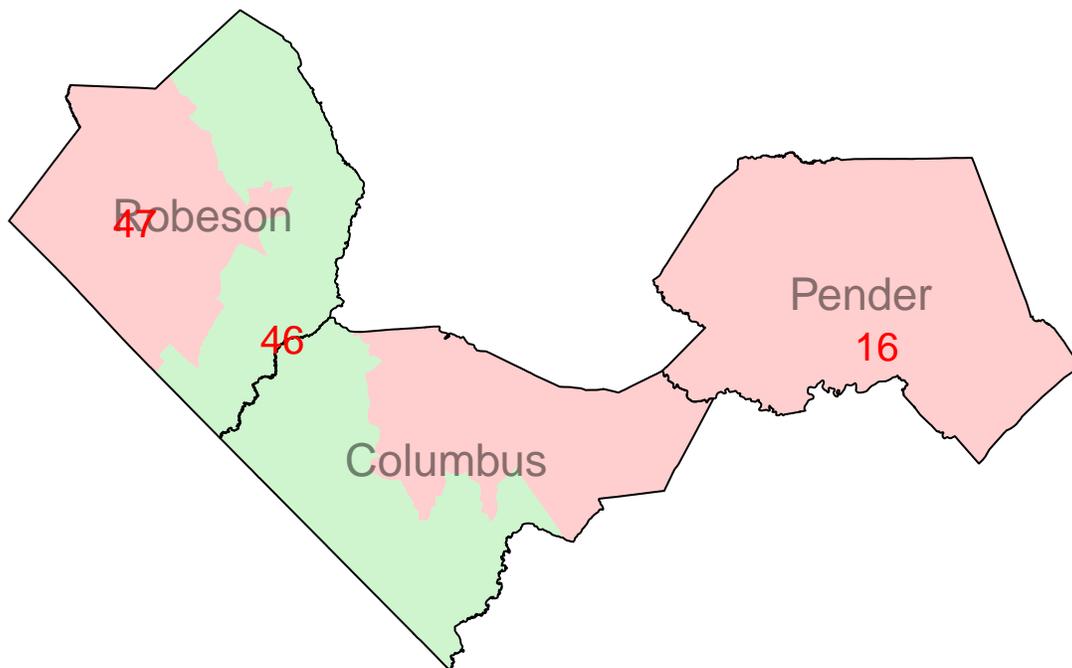
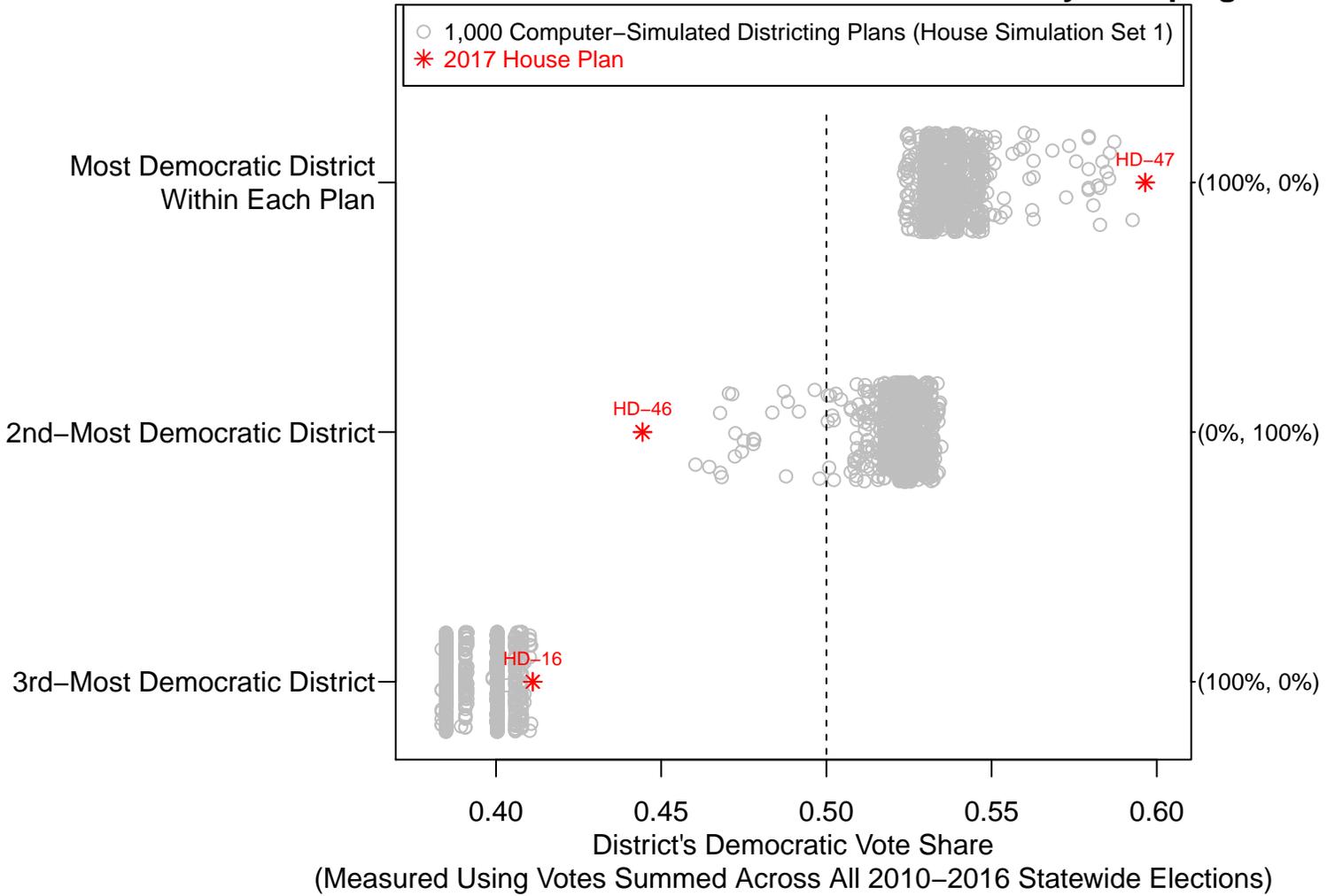
2017 Enacted House Plan Districts (6 total districts)
 (This county grouping includes 3 Special Master Districts (HD-57, HD-61, and HD-62)
 that are frozen in all simulated plans and not included in the above Figure)

**Figure 26: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Cabarrus-Davie-Montgomery-Richmond-Rowan-Stanly County Grouping**



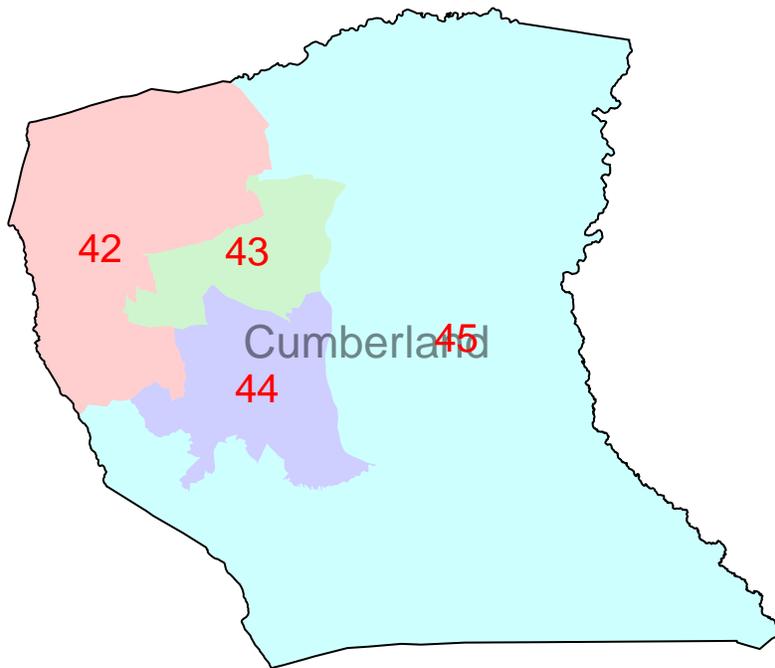
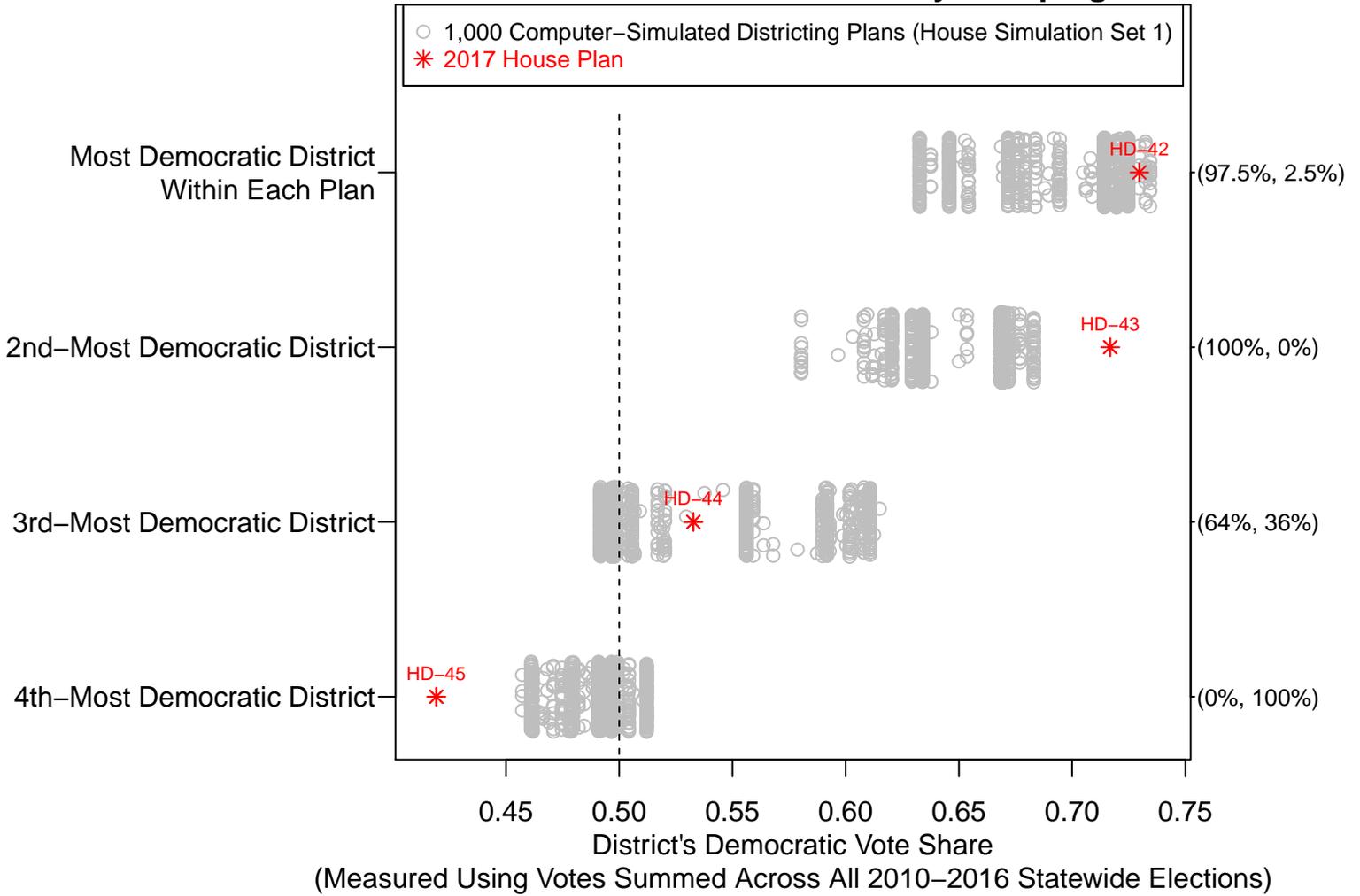
2017 Enacted House Plan Districts (6 Districts)

**Figure 27: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Columbus-Pender-Robeson County Grouping**



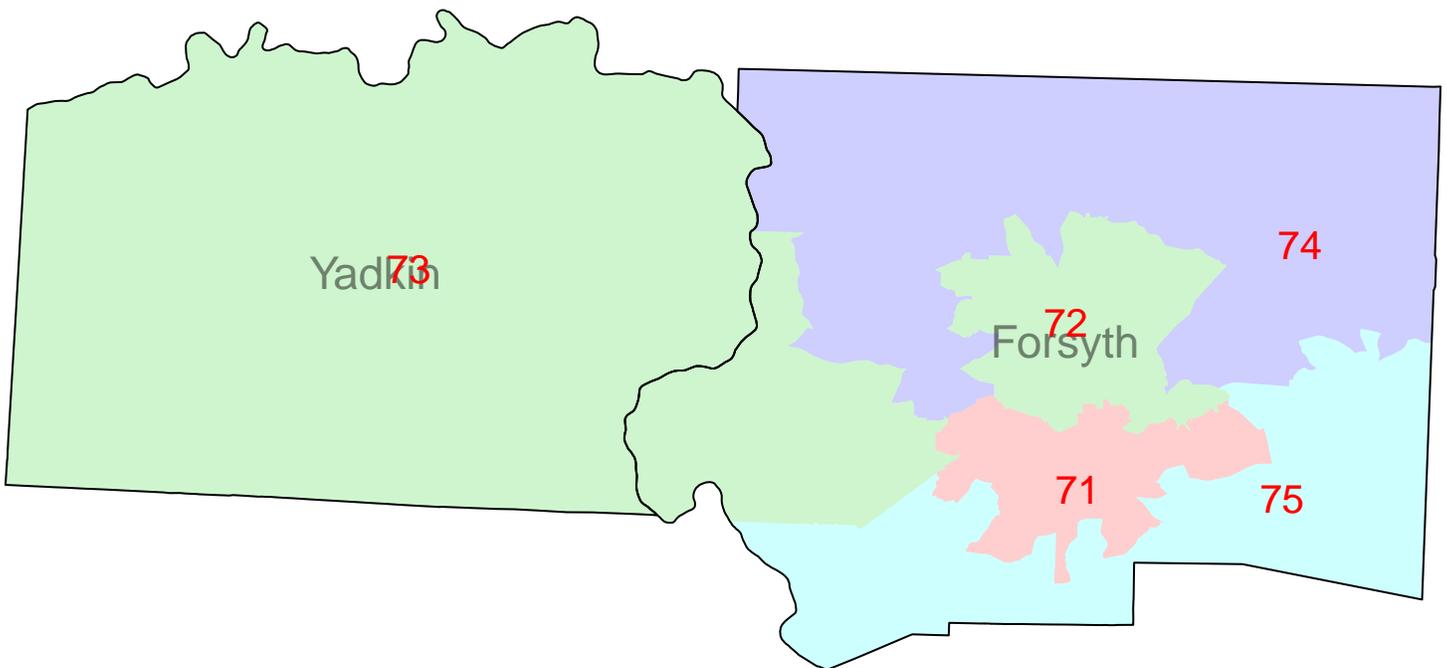
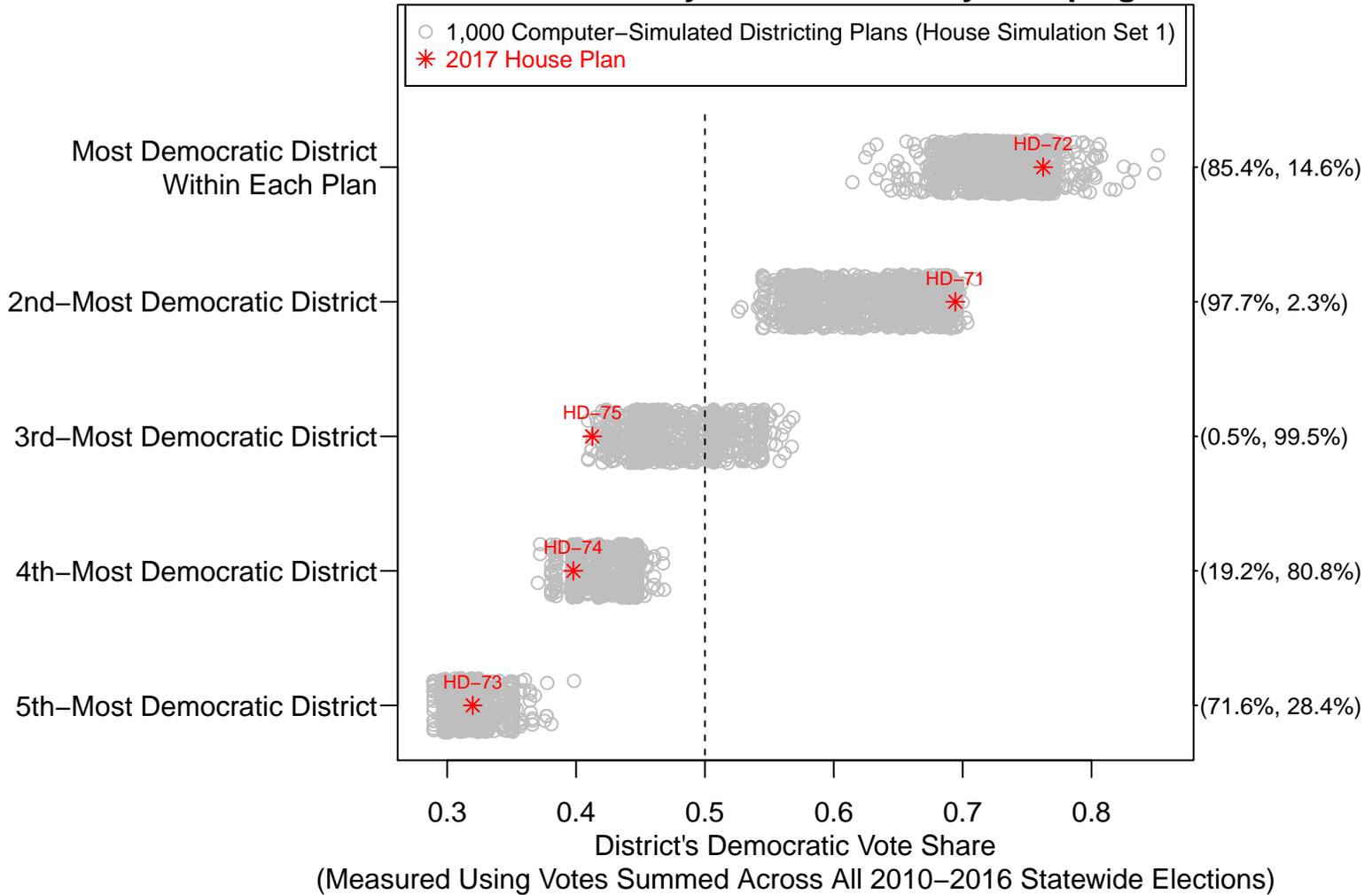
2017 Enacted House Plan Districts (3 Districts)

**Figure 28: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Cumberland County Grouping**



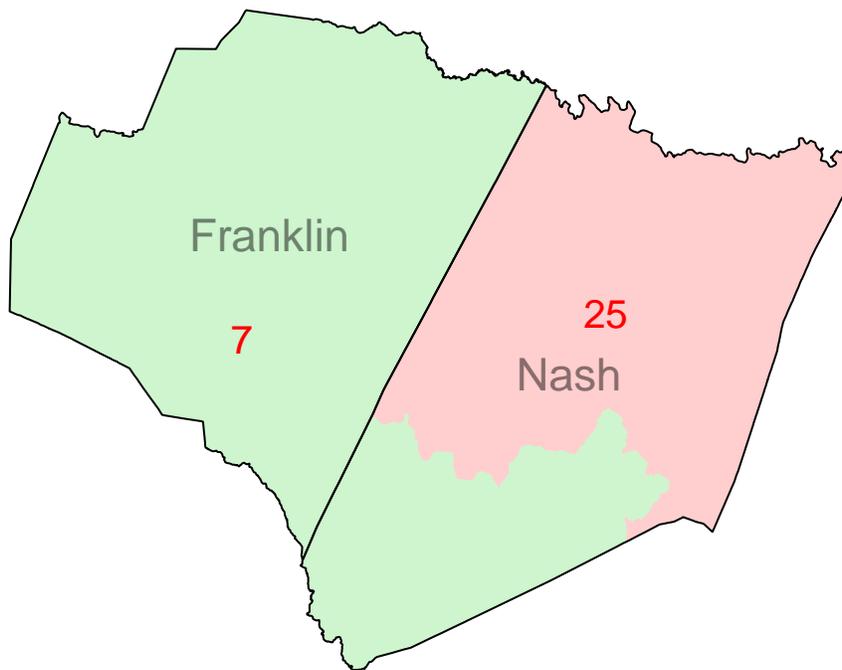
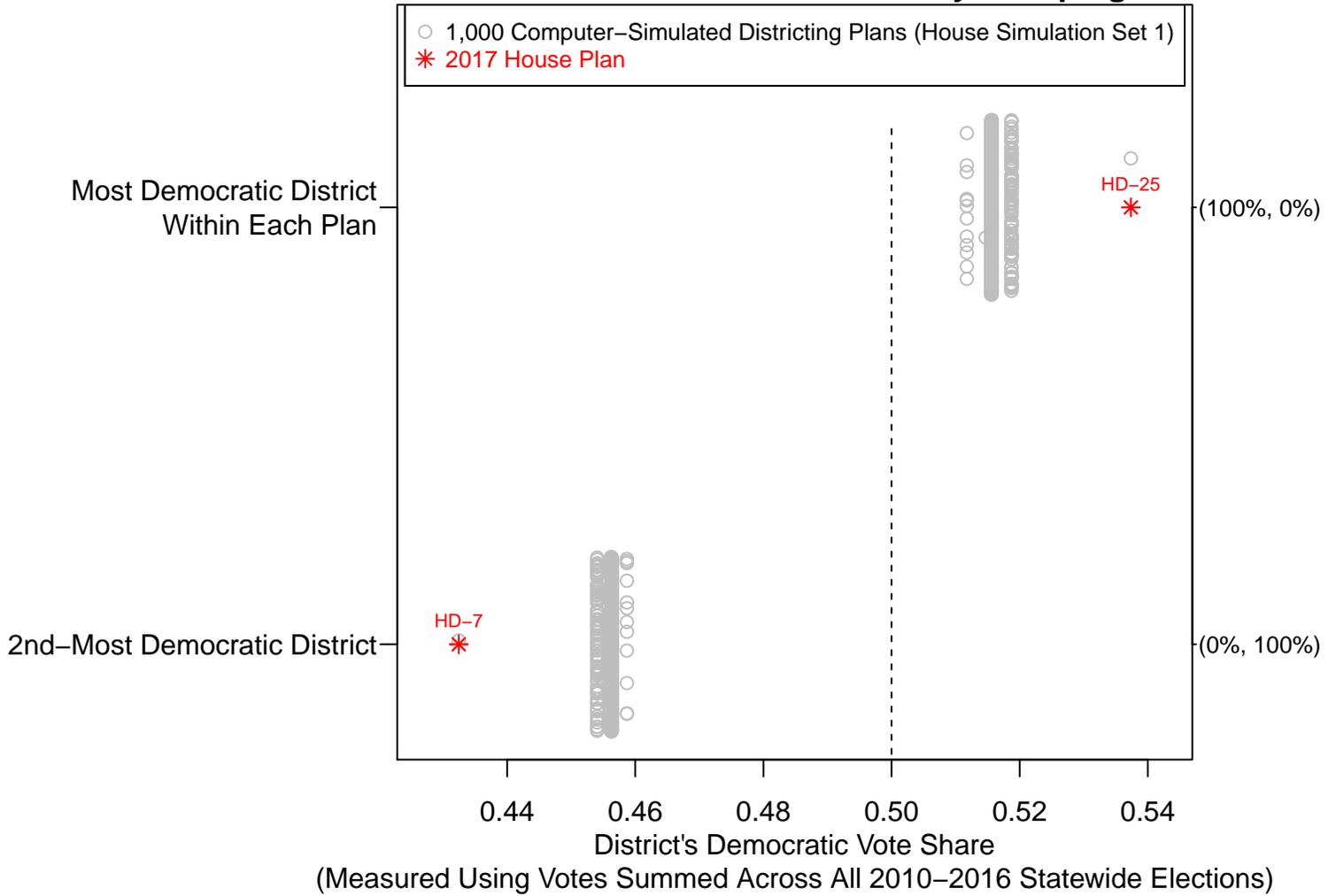
2017 Enacted House Plan Districts (4 Districts)

**Figure 29: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Forsyth–Yadkin County Grouping**



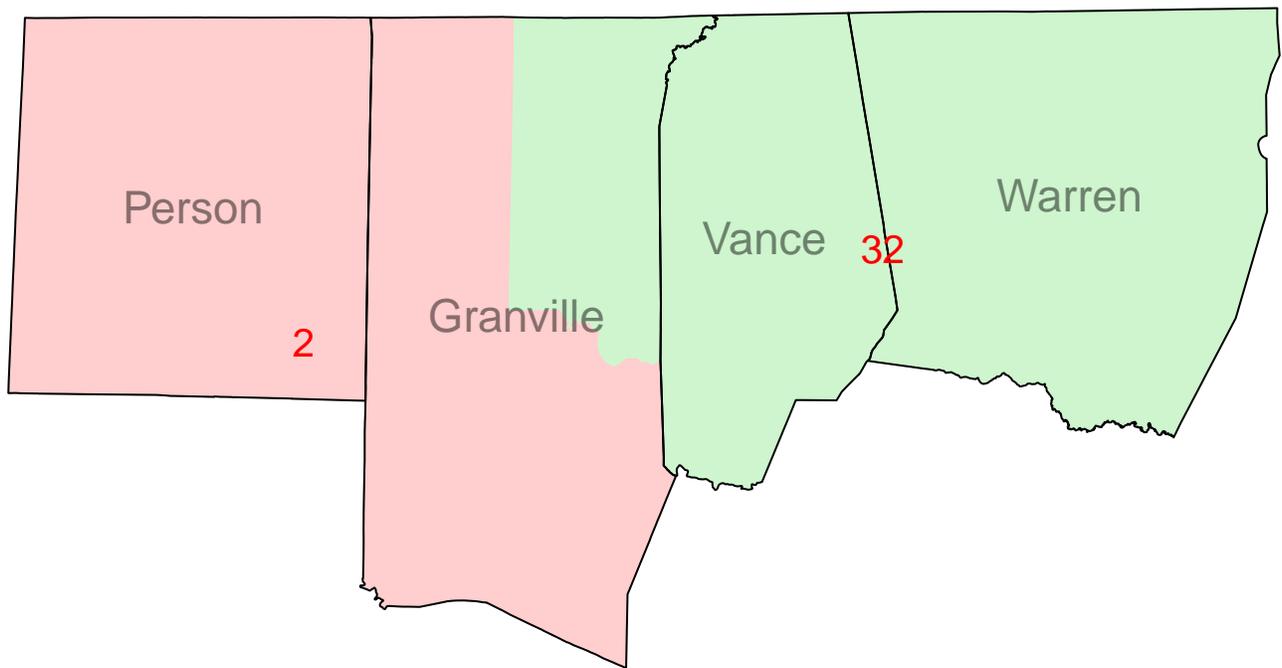
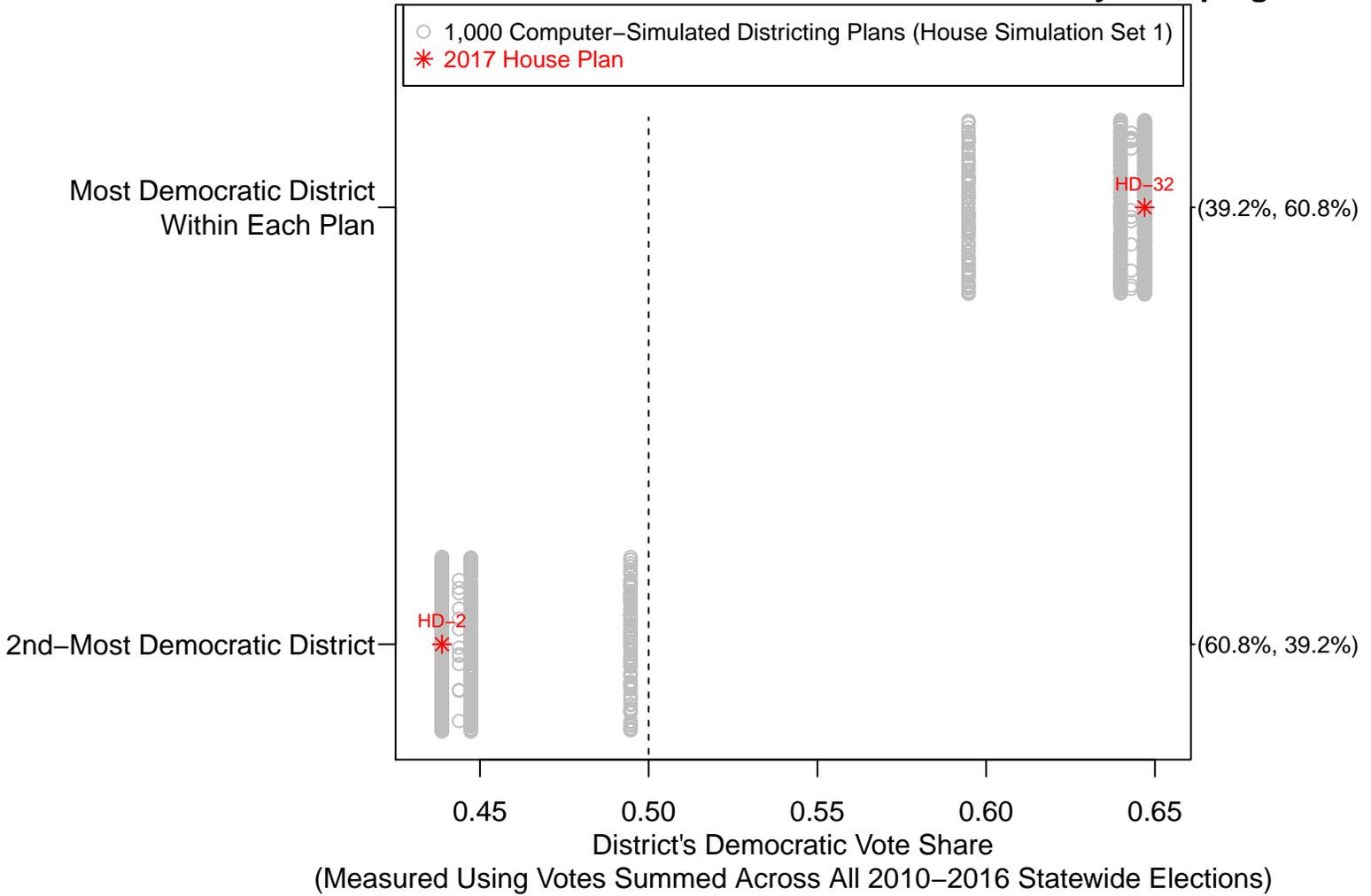
2017 Enacted House Plan Districts (5 Districts)

**Figure 30: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Franklin-Nash County Grouping**

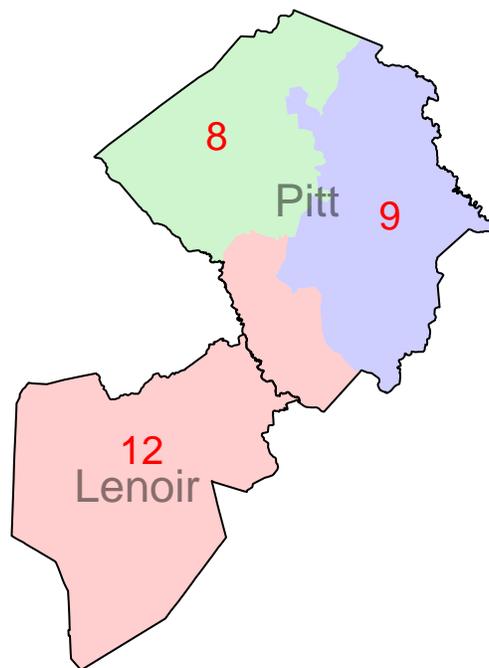
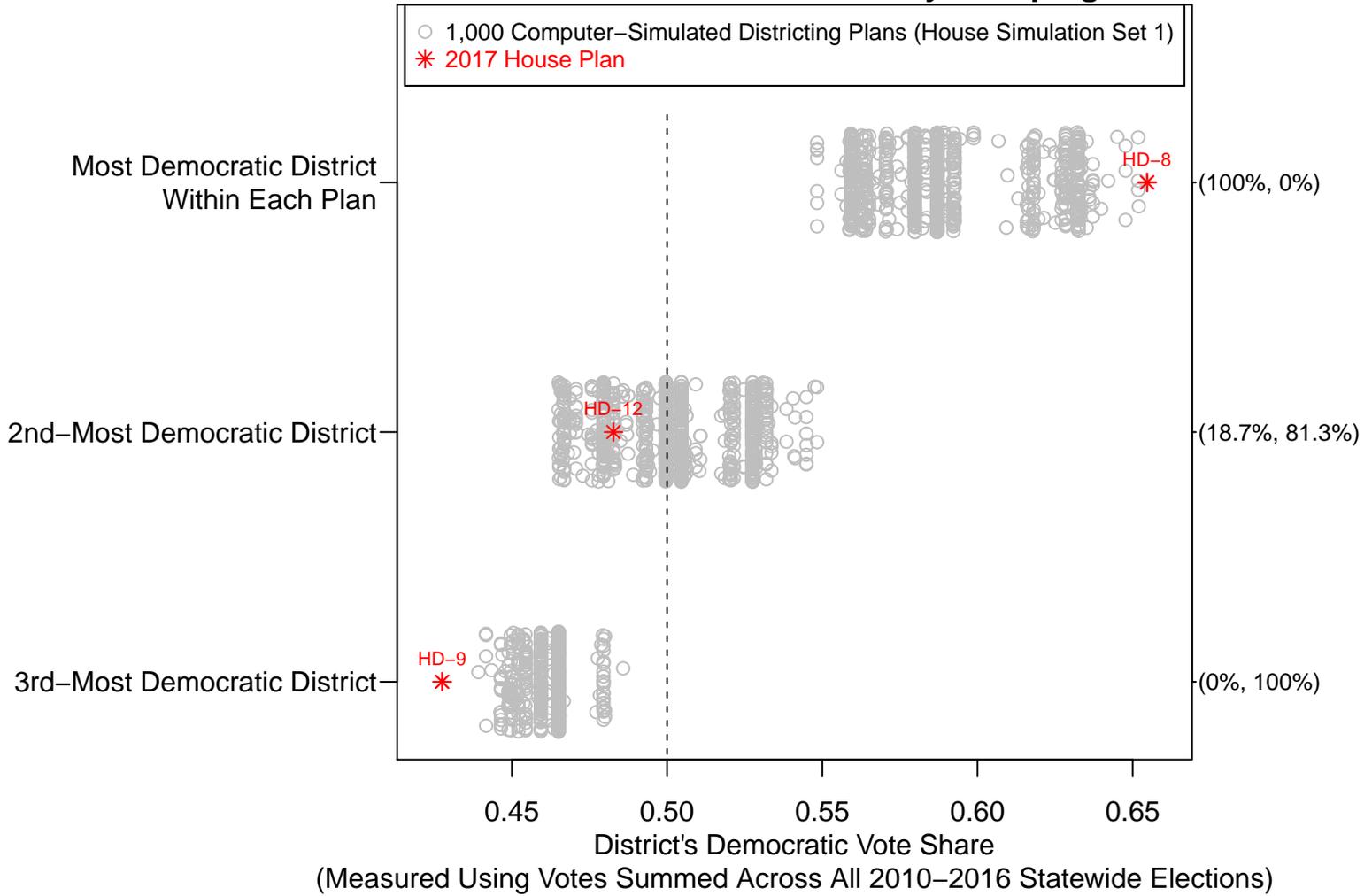


2017 Enacted House Plan Districts (2 Districts)

**Figure 31: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Granville–Person–Vance–Warren County Grouping**

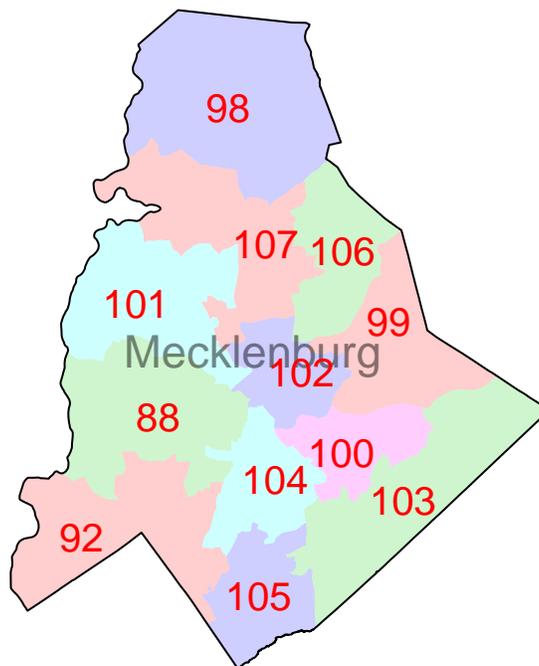
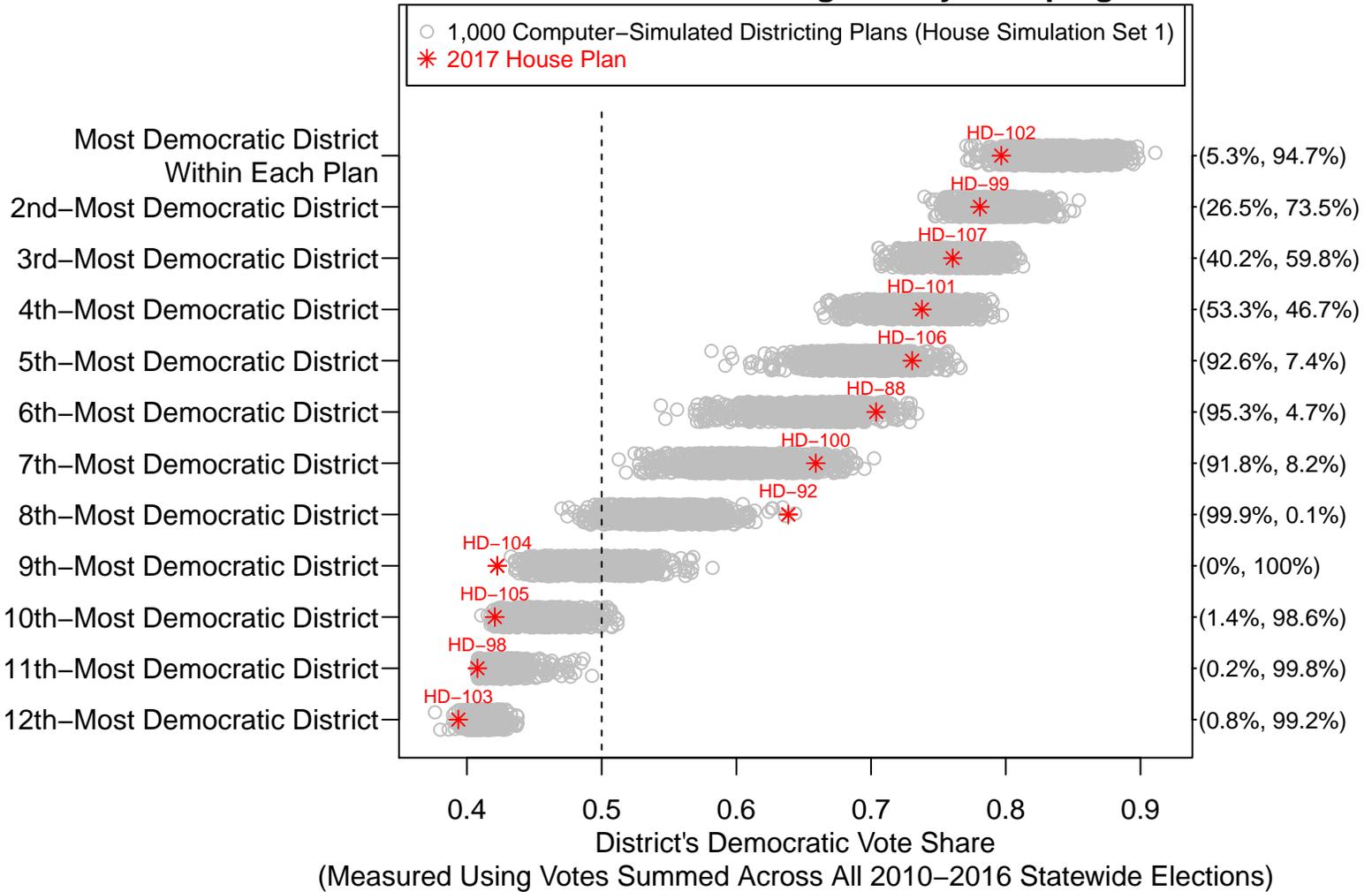


**Figure 32: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Lenoir-Pitt County Grouping**



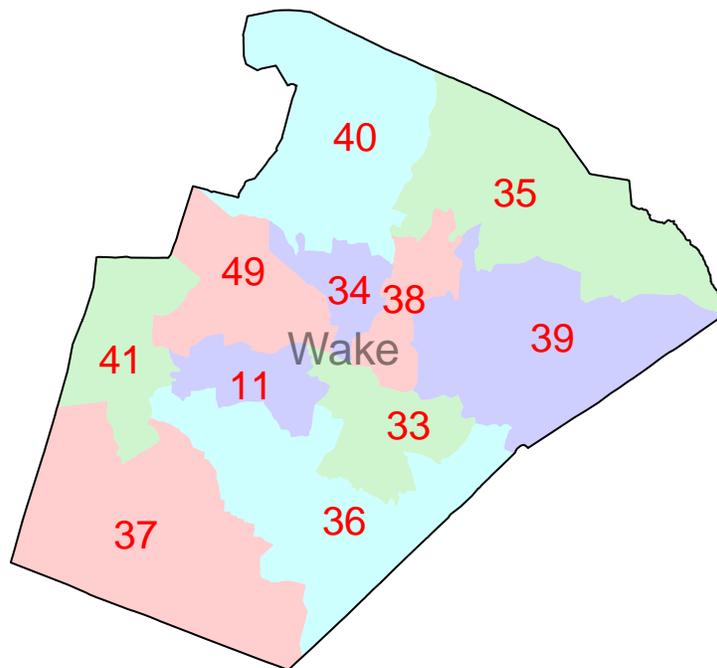
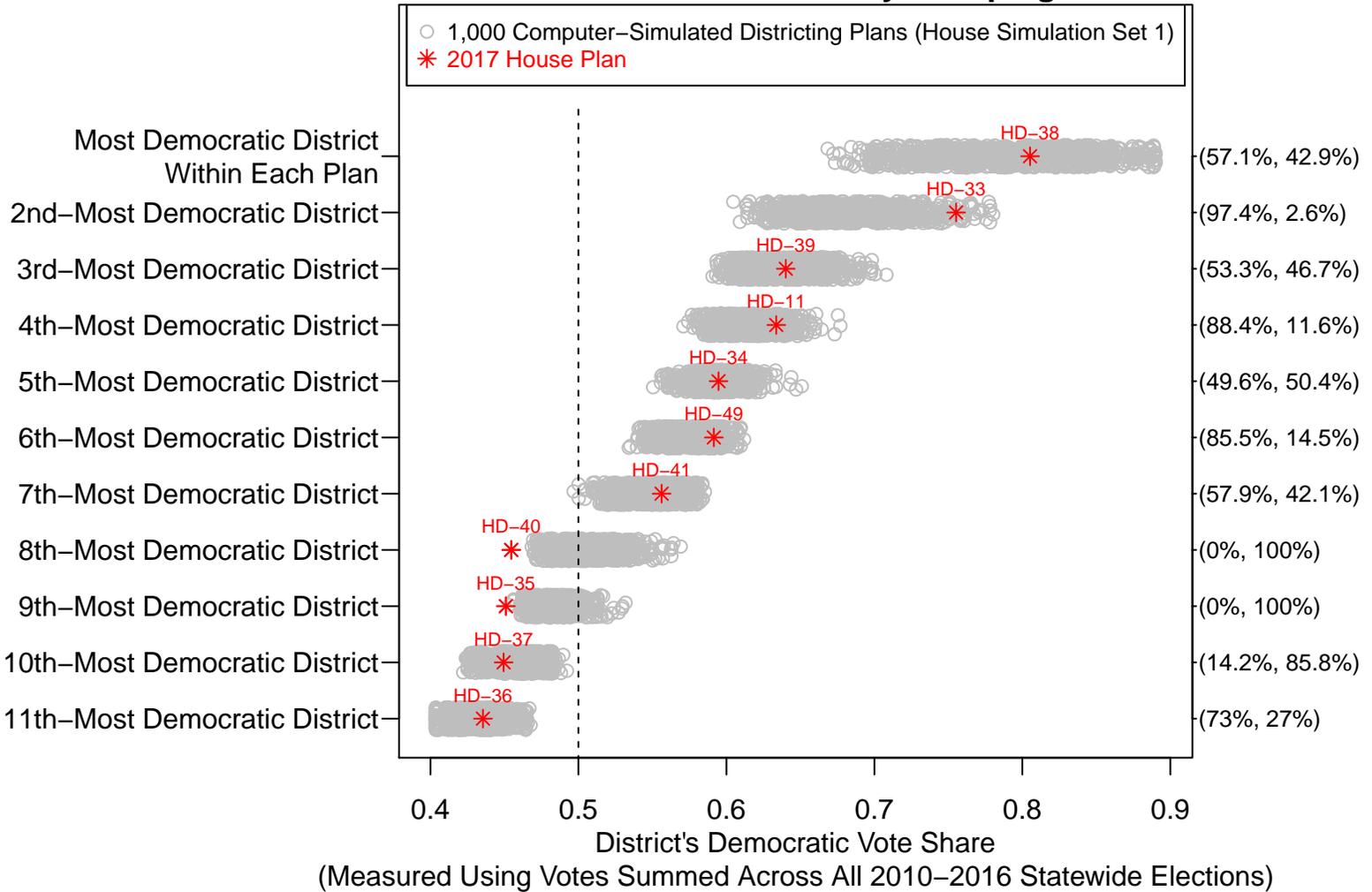
2017 Enacted House Plan Districts (3 Districts)

**Figure 33: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Mecklenburg County Grouping**



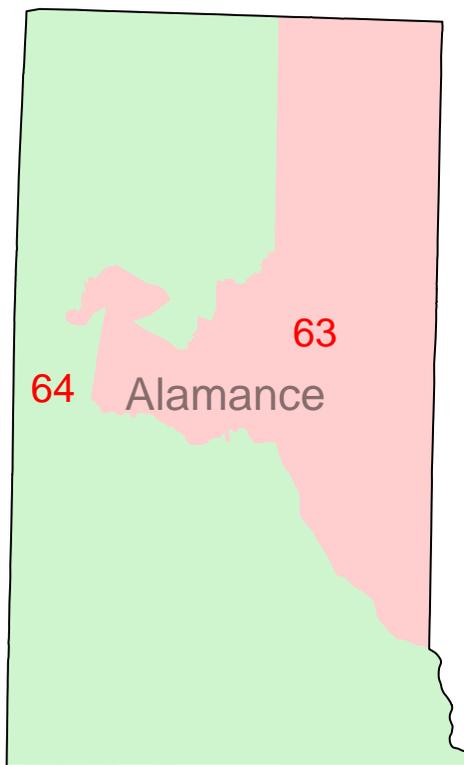
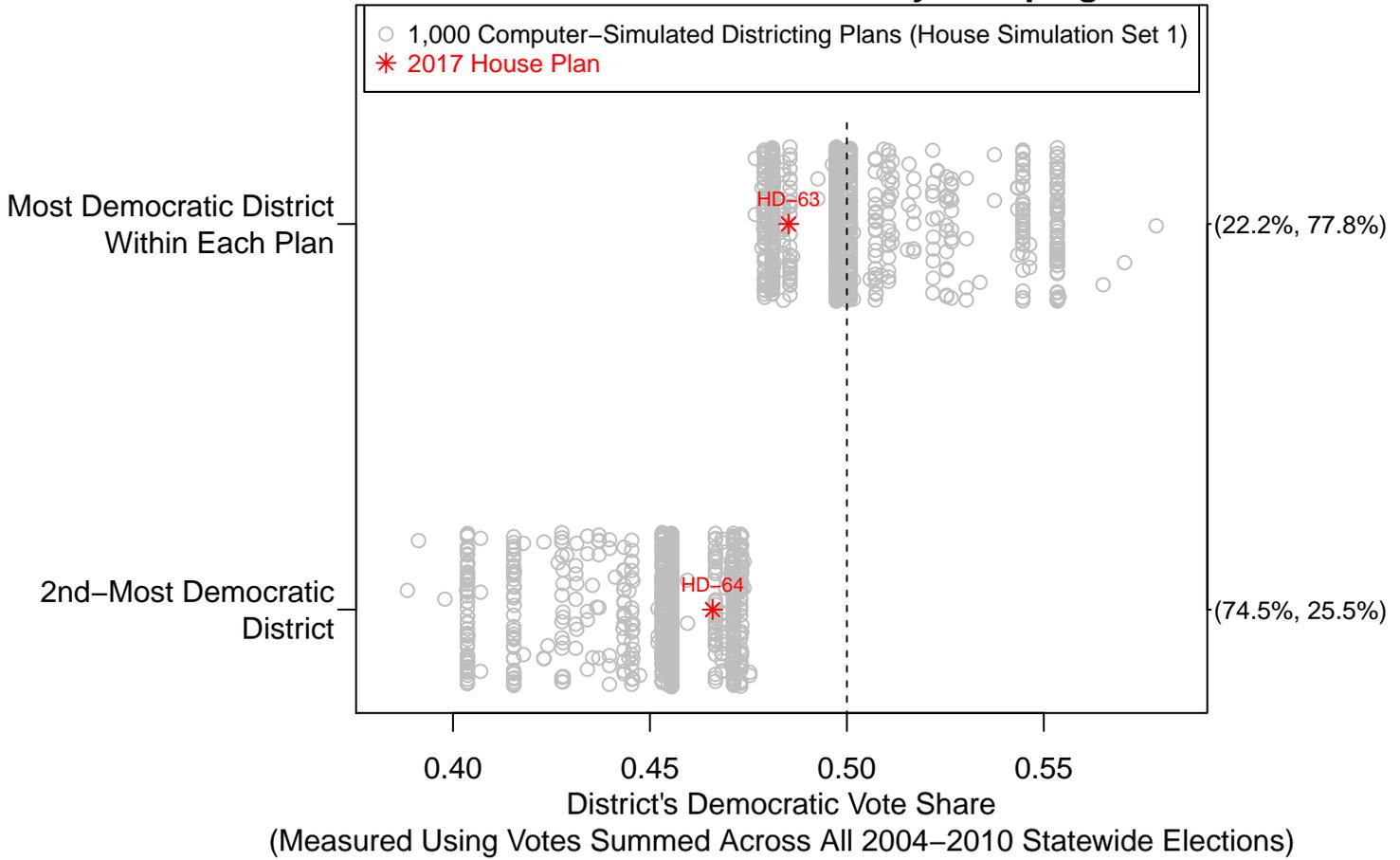
2017 Enacted House Plan Districts (12 Districts)

**Figure 34: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Wake County Grouping**



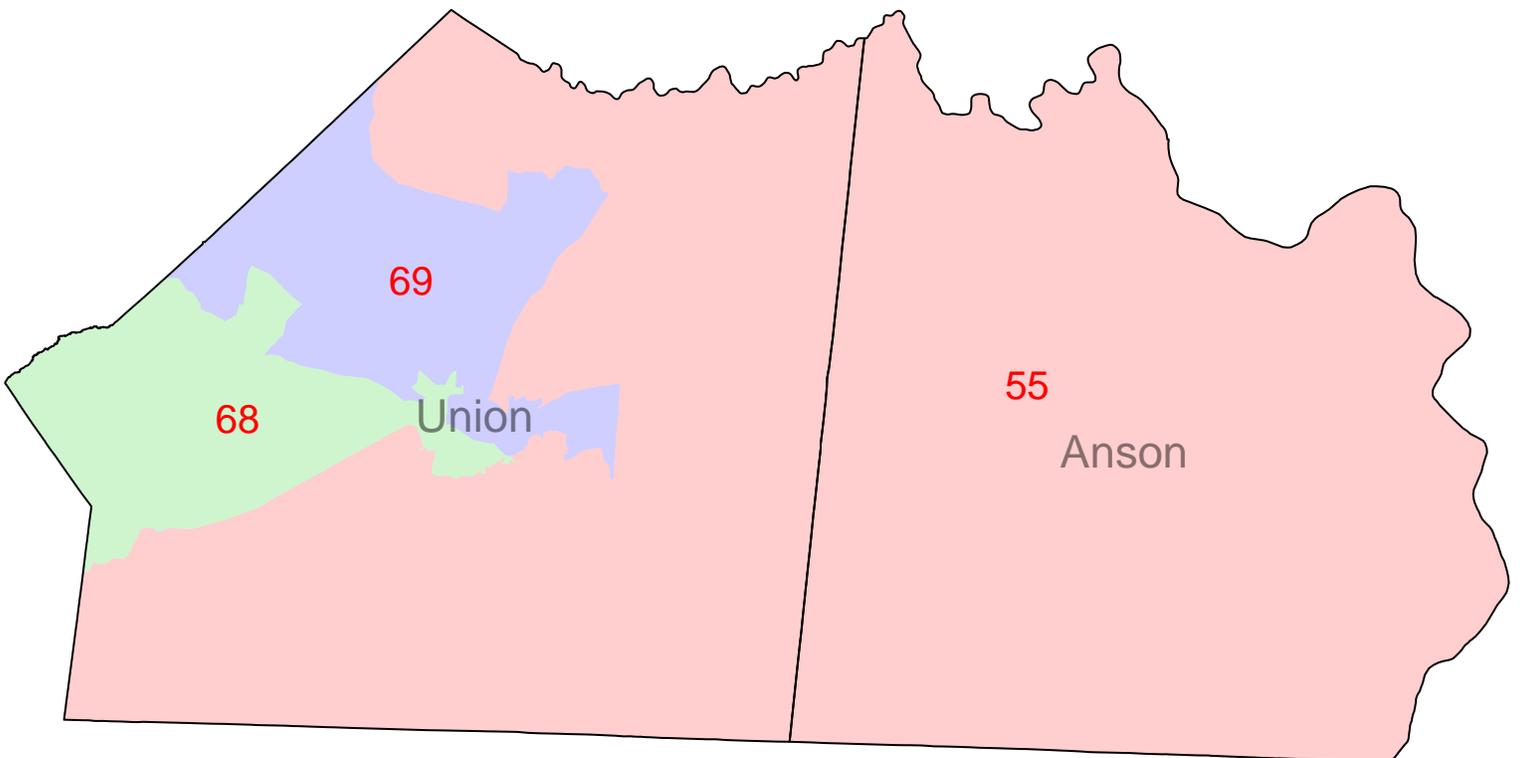
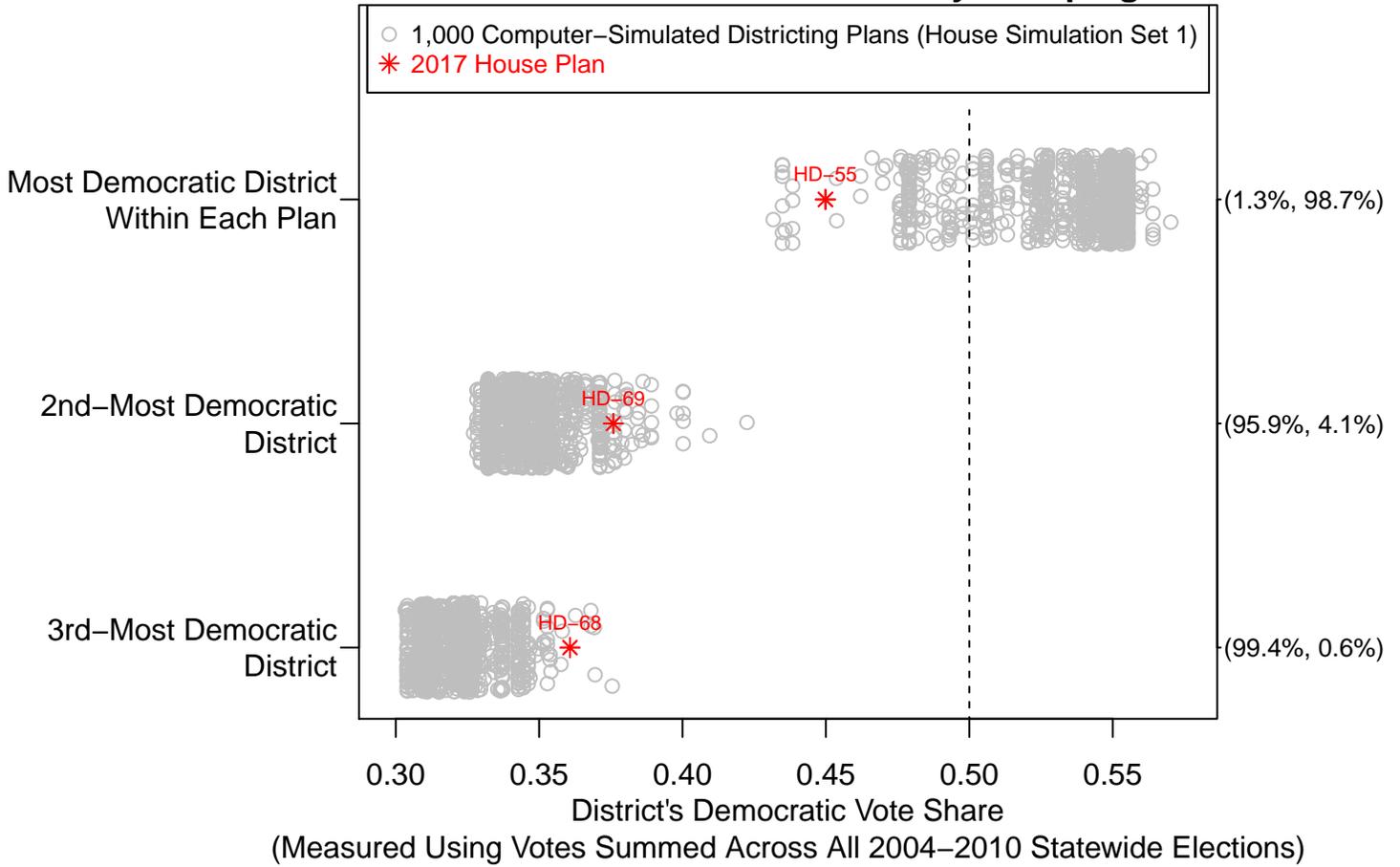
2017 Enacted House Plan Districts (11 Districts)

**Figure 35: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Alamance County Grouping**

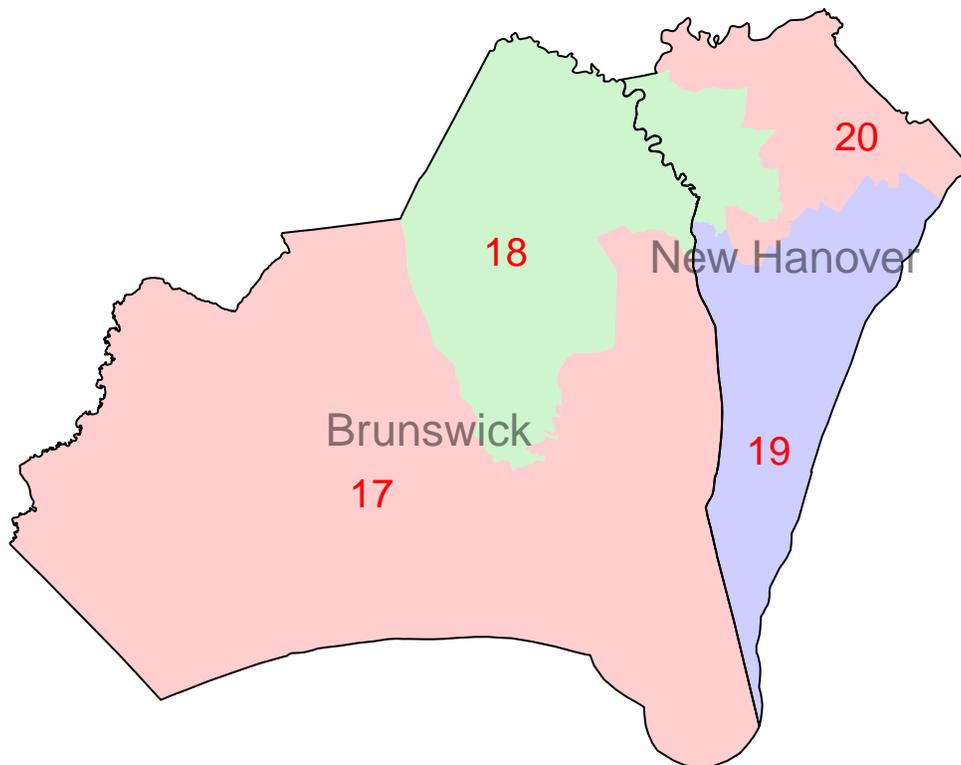
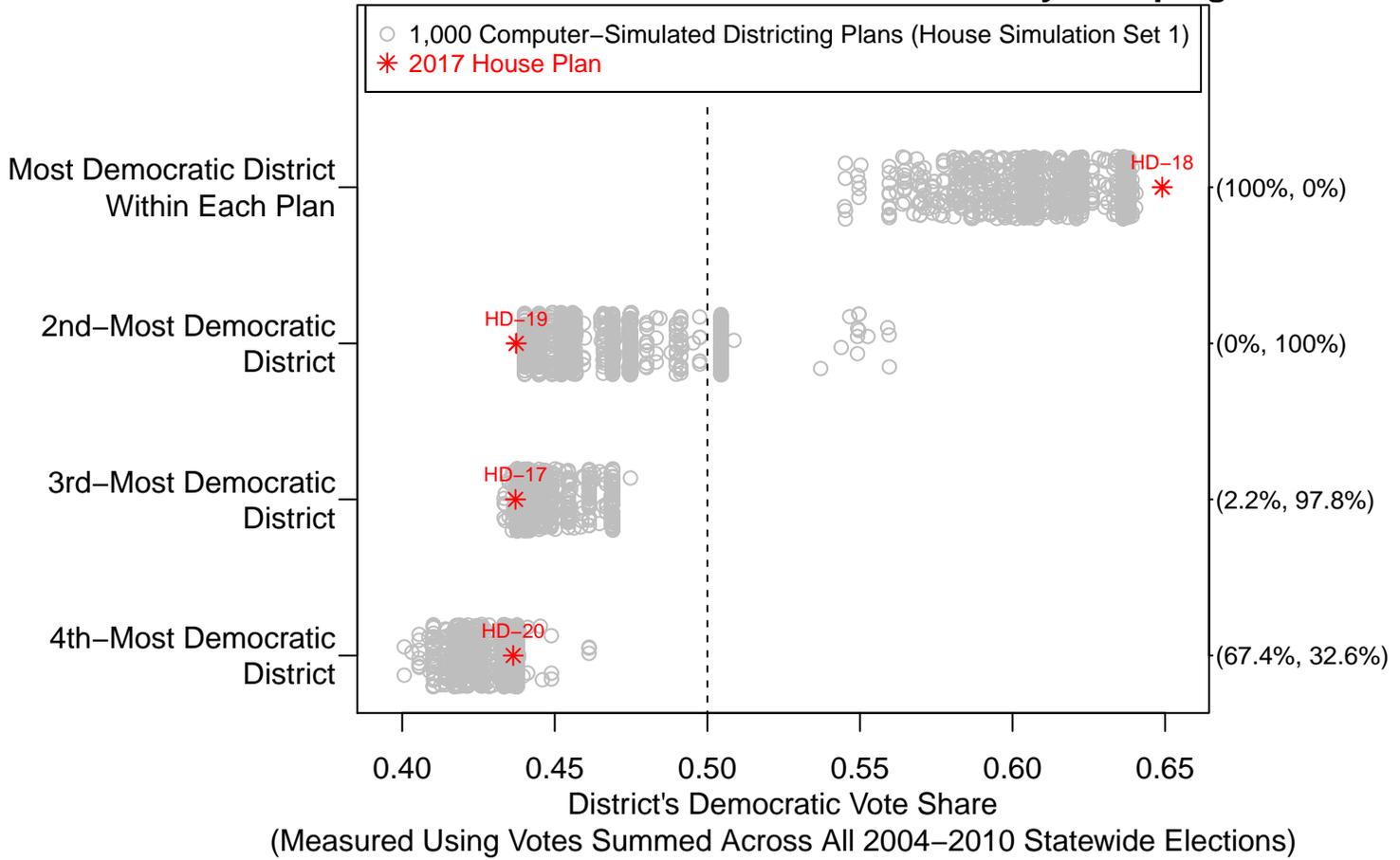


2017 Enacted House Plan Districts (2 Districts)

**Figure 36: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Anson-Union County Grouping**

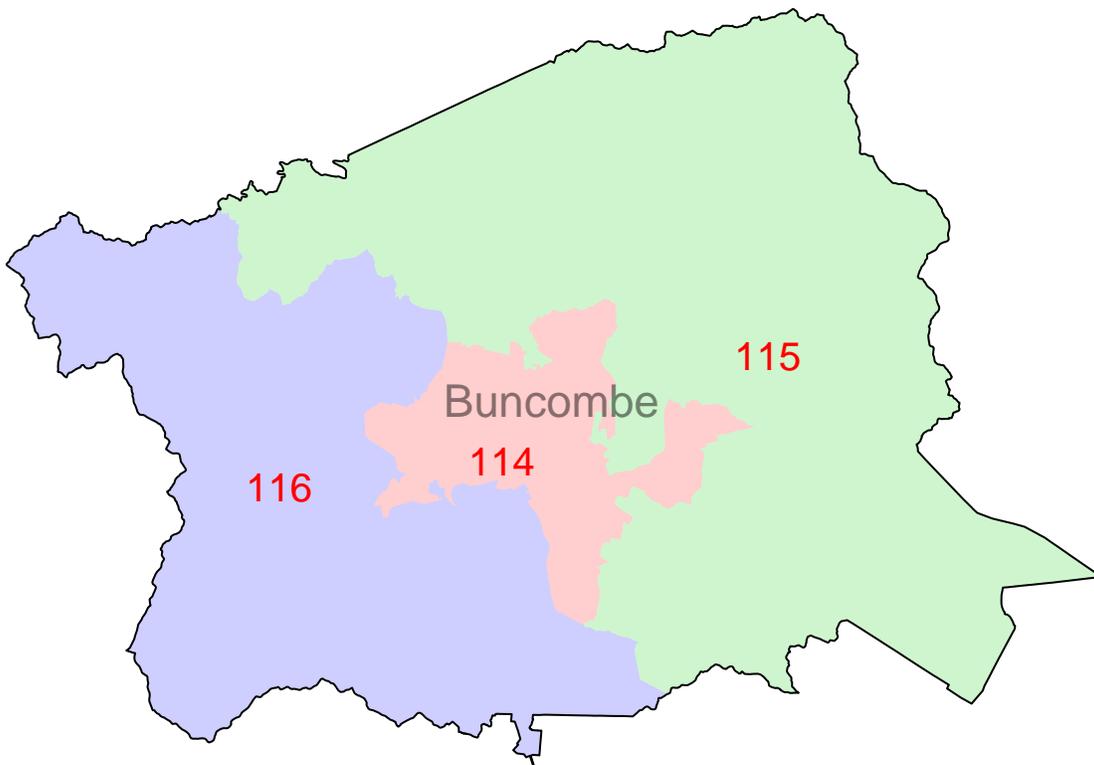
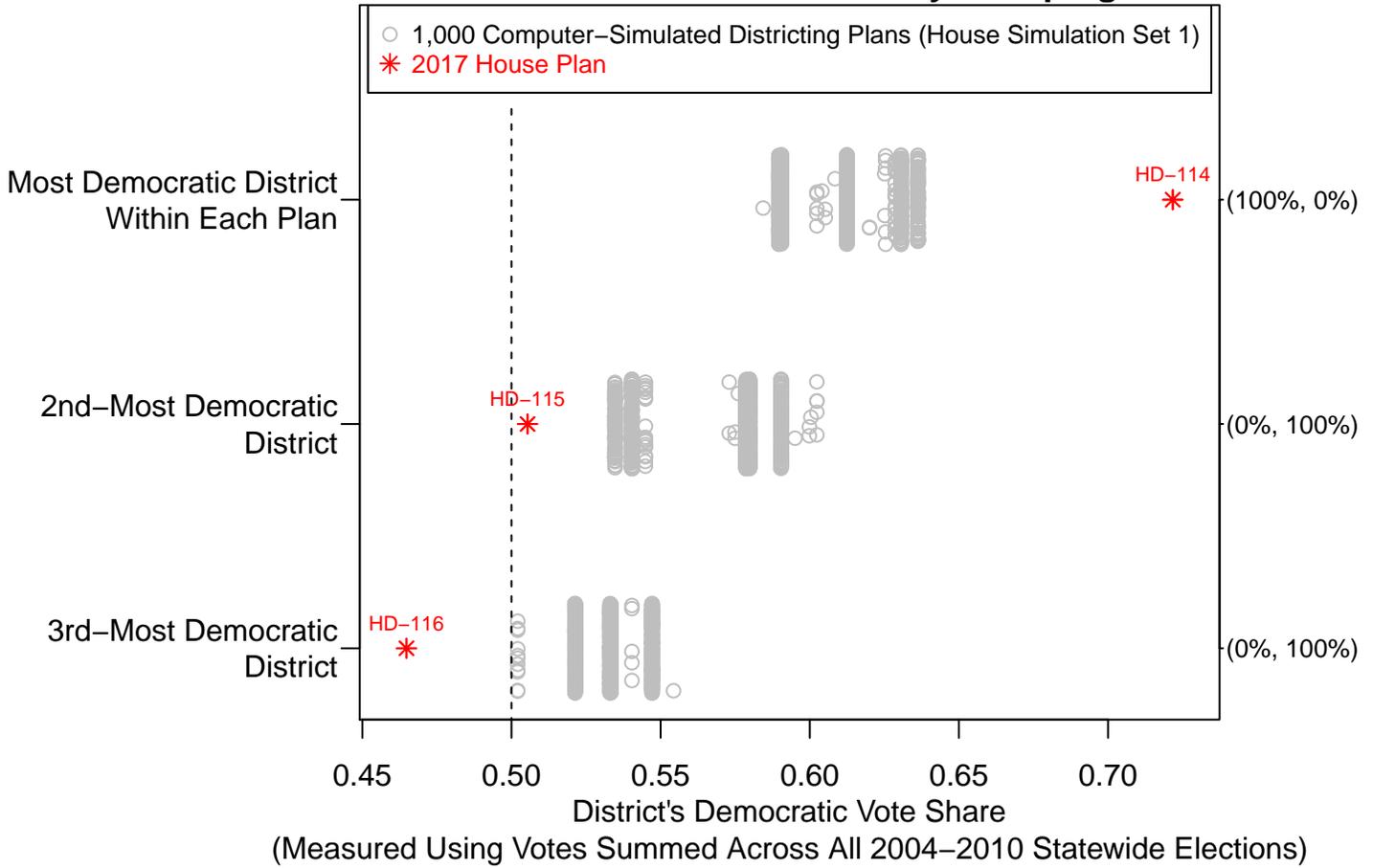


**Figure 37: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Brunswick–New Hanover County Grouping**



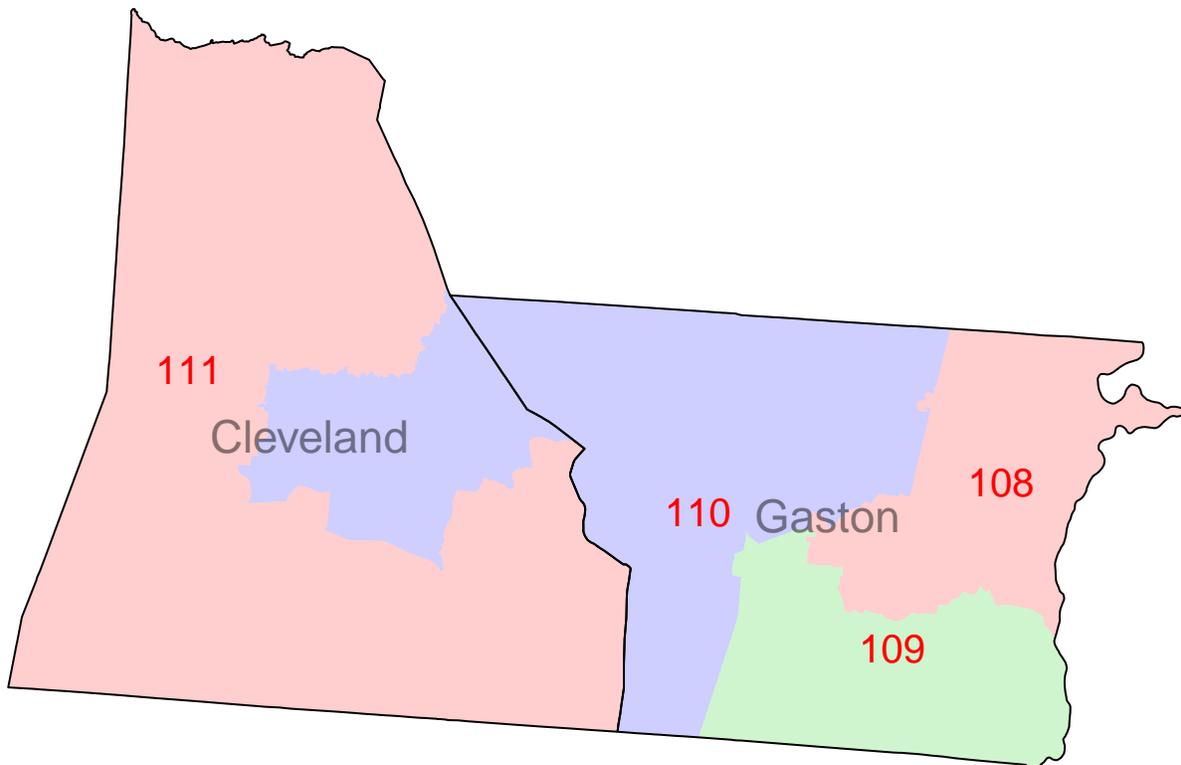
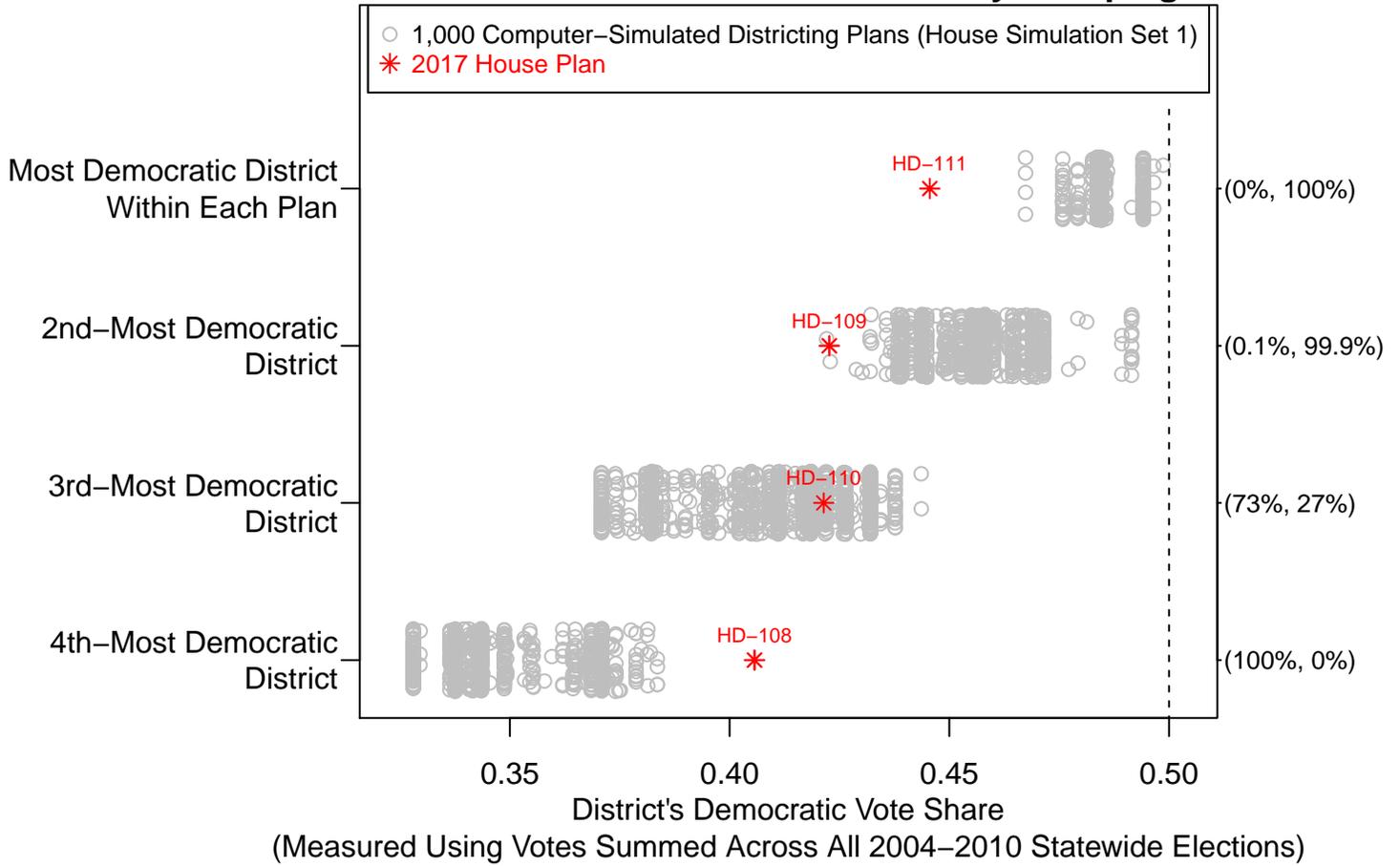
2017 Enacted House Plan Districts (4 Districts)

**Figure 38: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Buncombe County Grouping**



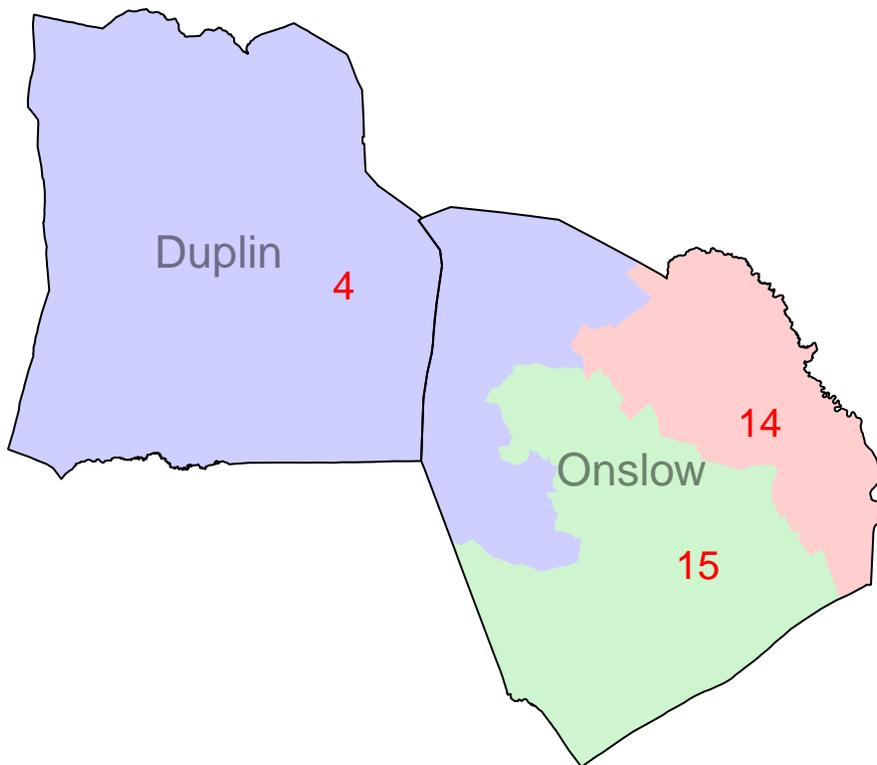
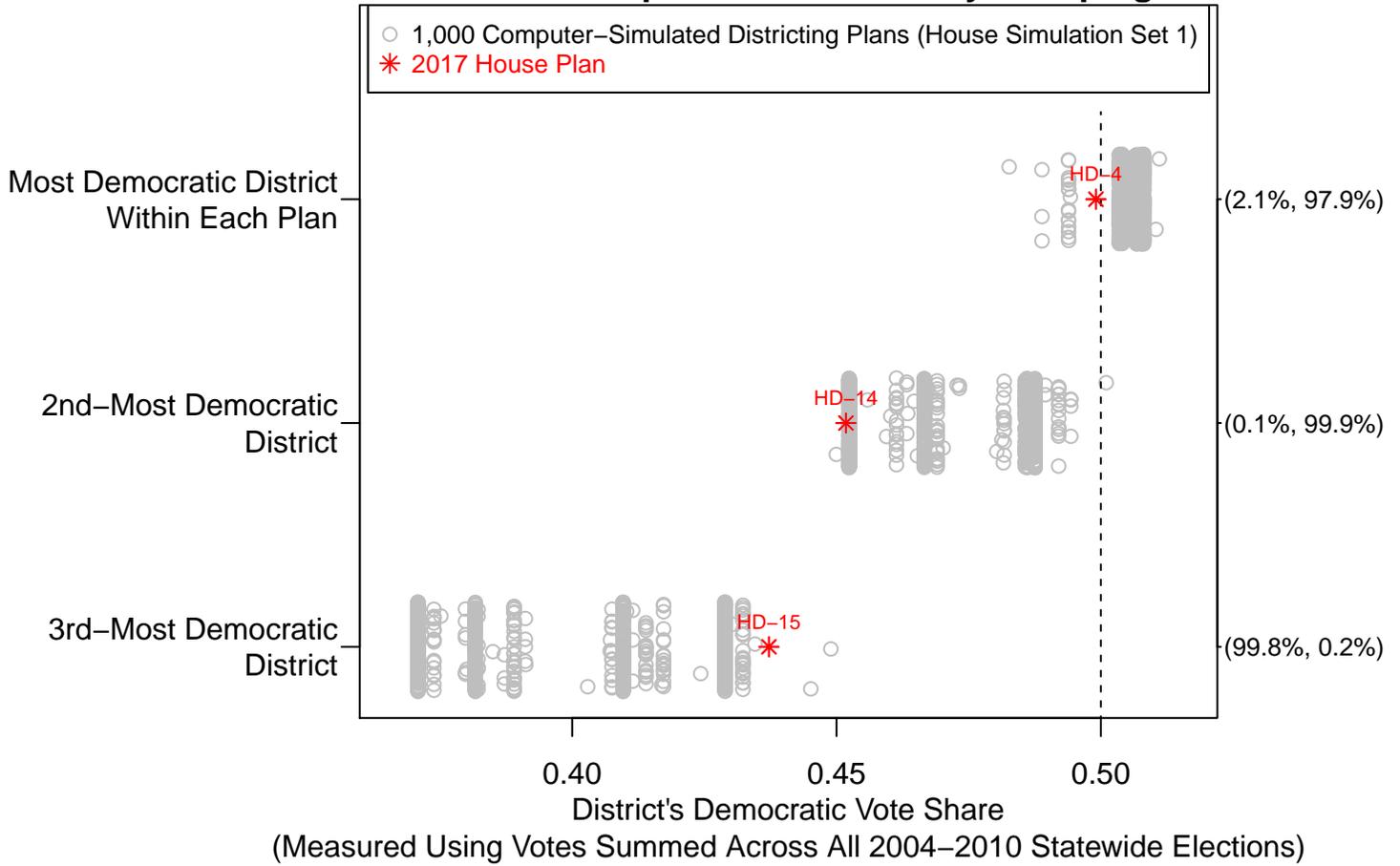
2017 Enacted House Plan Districts (3 Districts)

**Figure 39: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Cleveland-Gaston County Grouping**



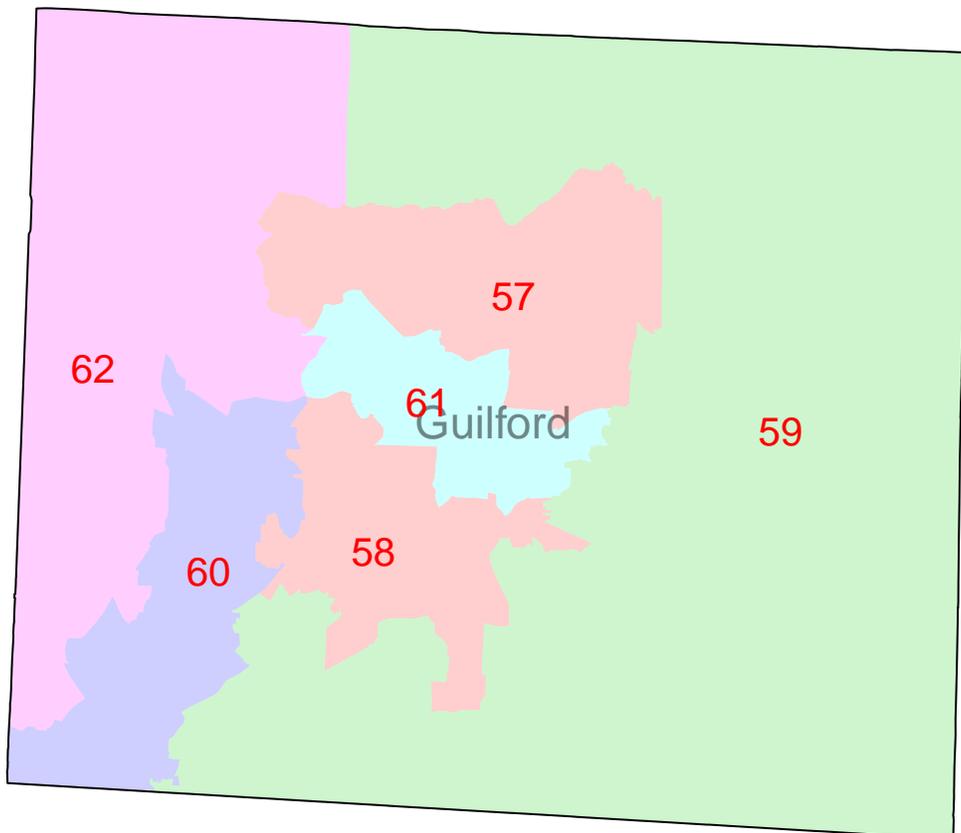
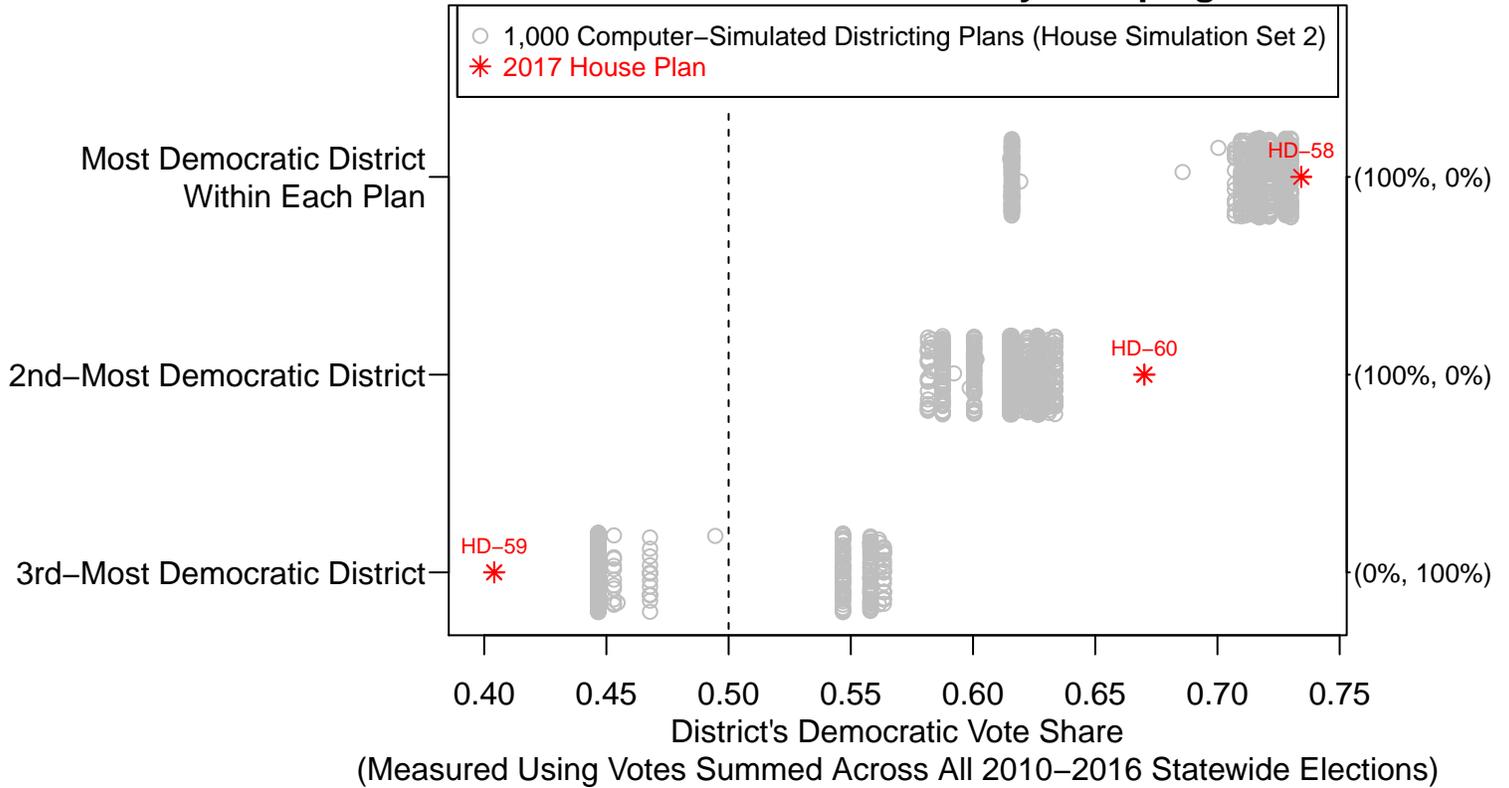
2017 Enacted House Plan Districts (4 Districts)

**Figure 40: House Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Duplin-Onslow County Grouping**



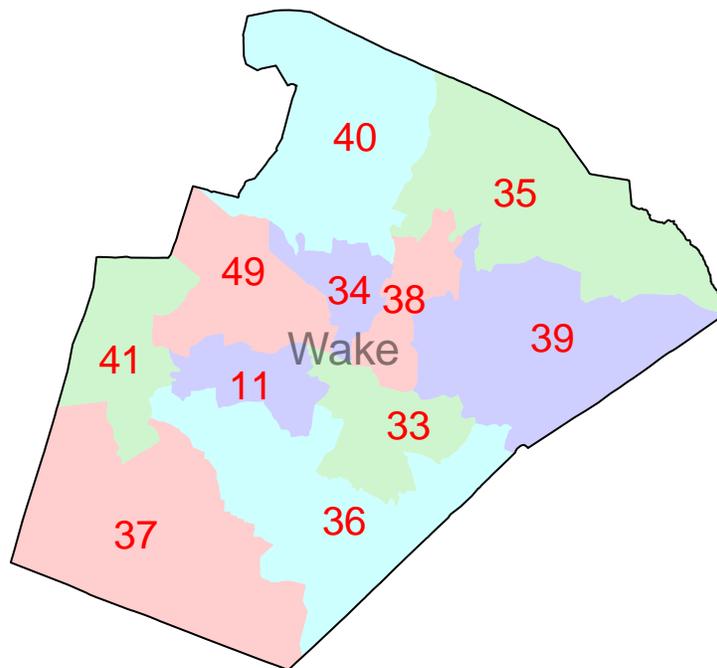
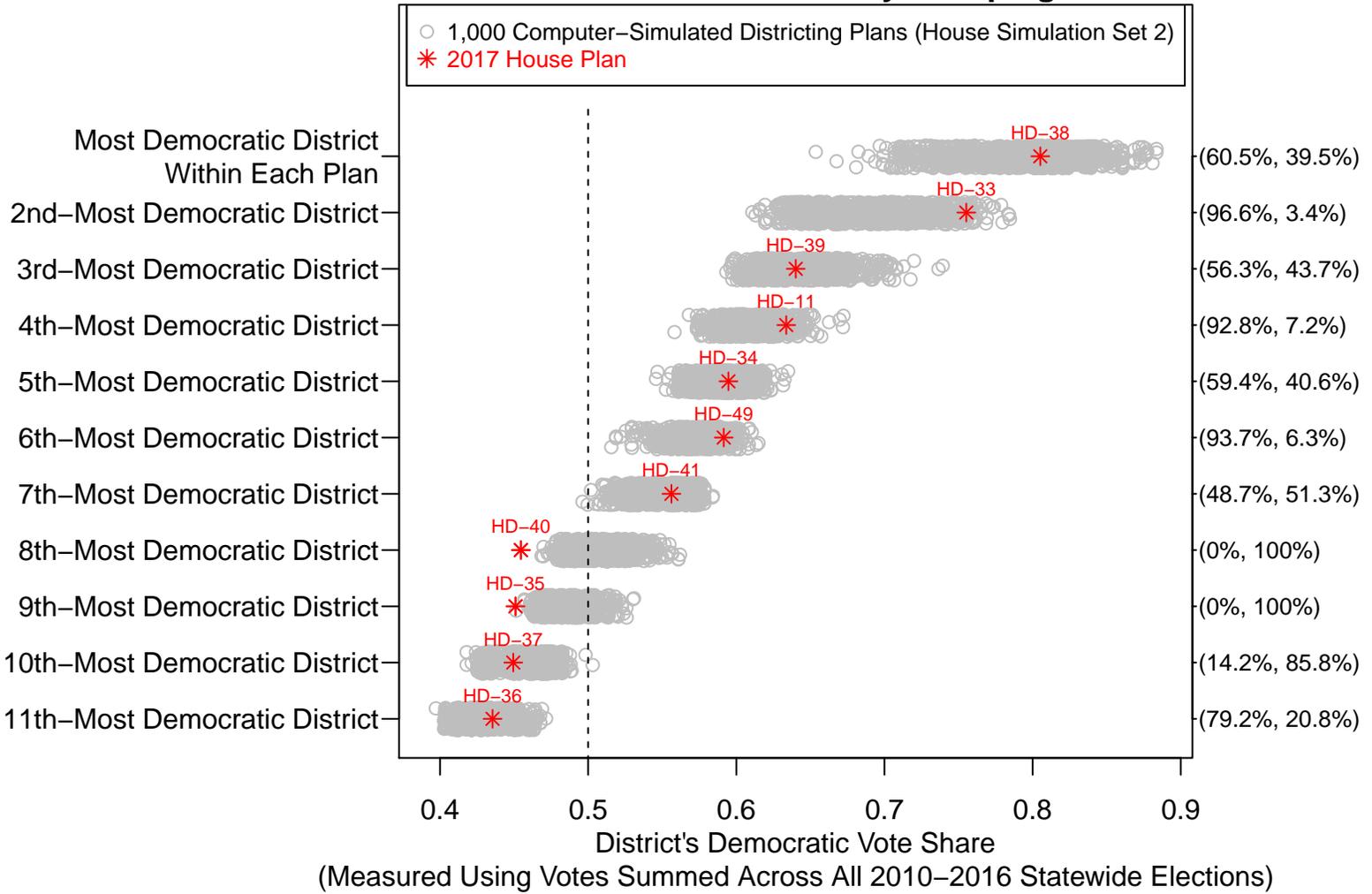
2017 Enacted House Plan Districts (3 Districts)

**Figure 41: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Guilford County Grouping**



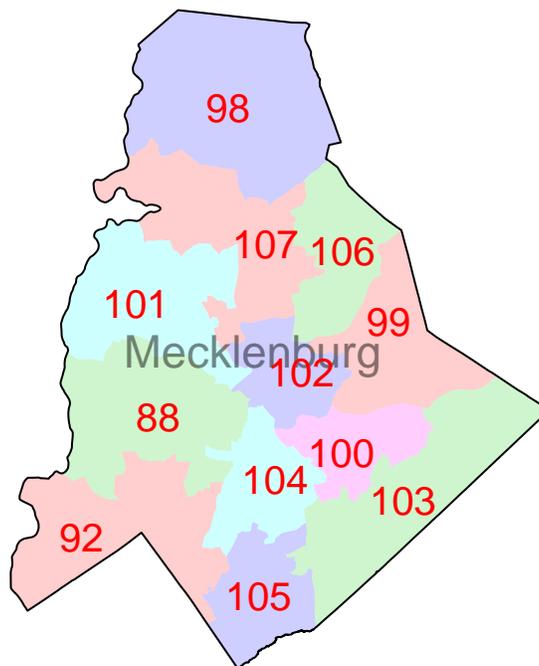
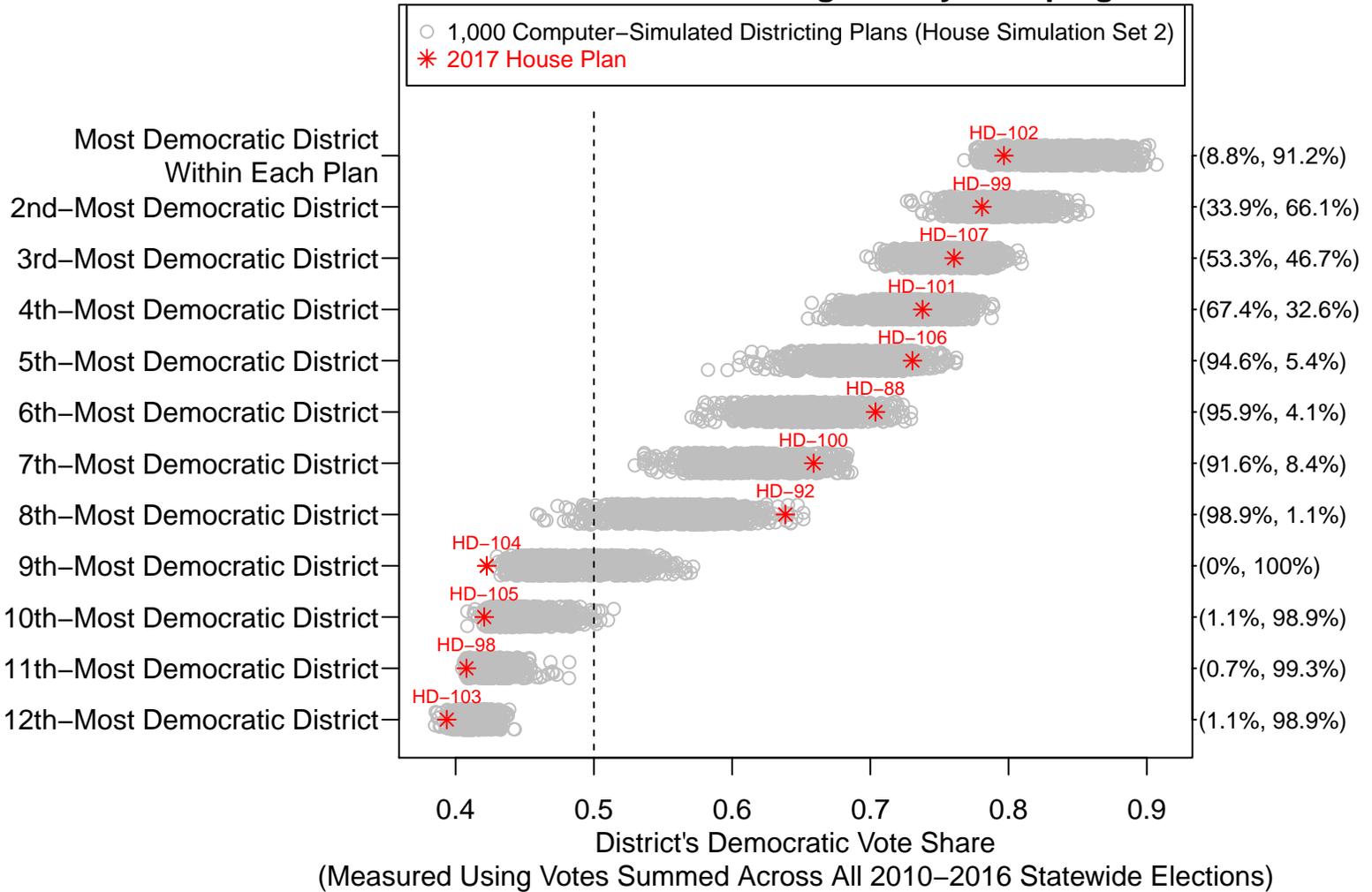
2017 Enacted House Plan Districts (6 total districts)
 (This county grouping includes 3 Special Master Districts (HD-57, HD-61, and HD-62)
 that are frozen in all simulated plans and not included in the above Figure)

**Figure 42: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Wake County Grouping**



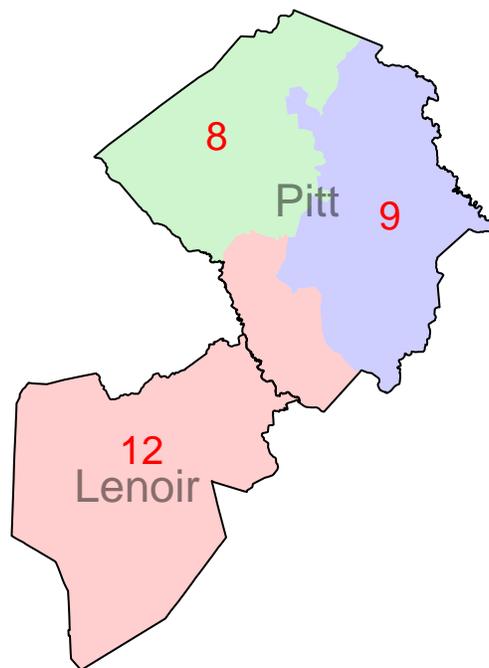
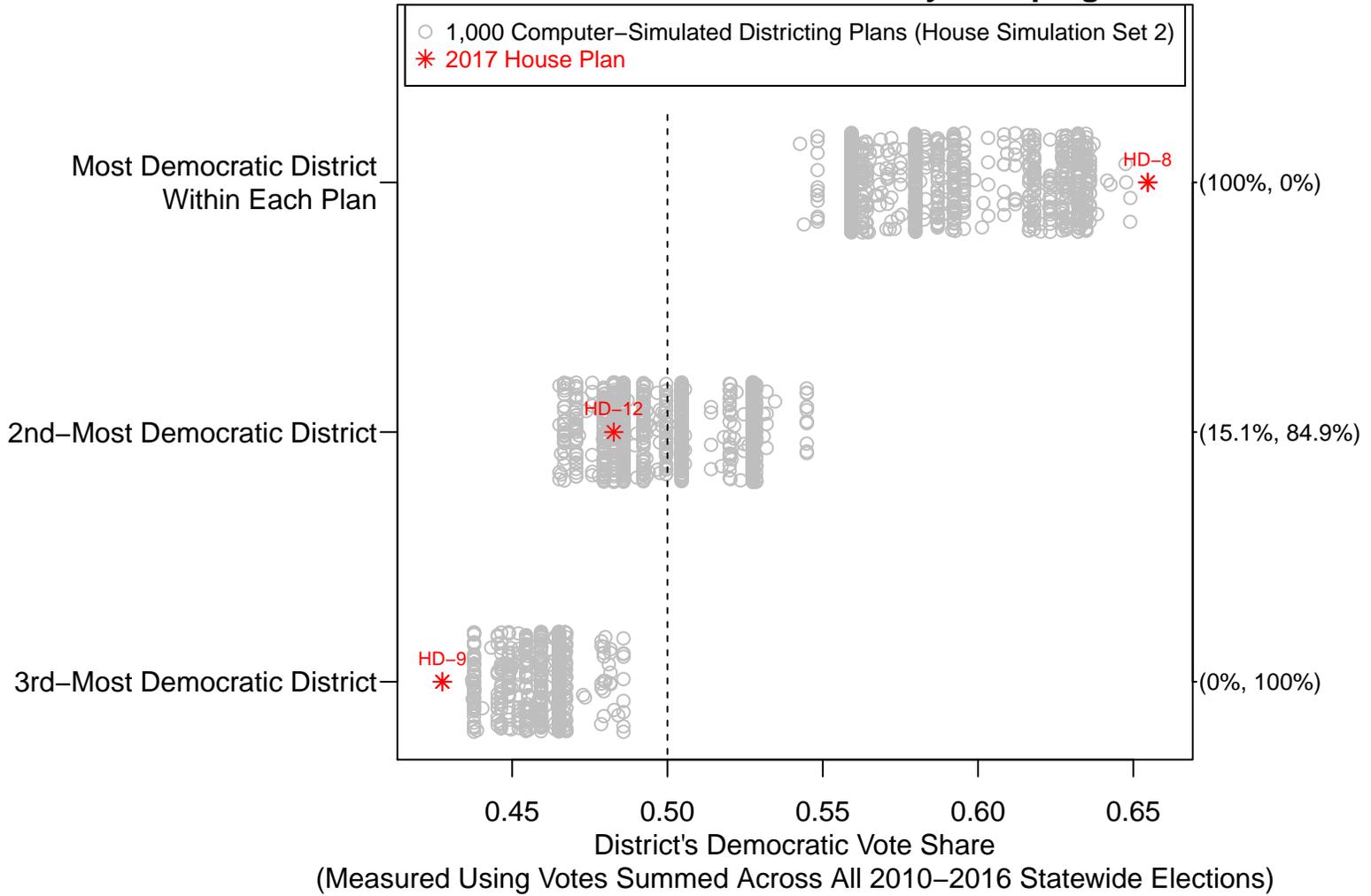
2017 Enacted House Plan Districts (11 Districts)

**Figure 43: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Mecklenburg County Grouping**



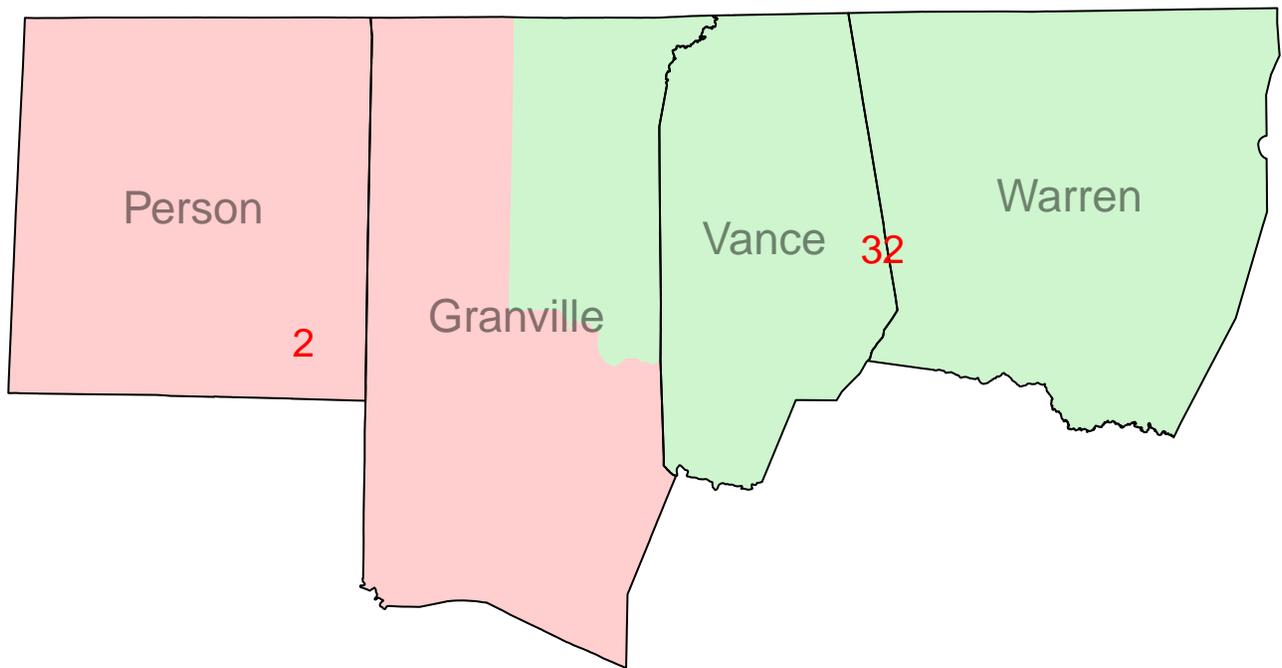
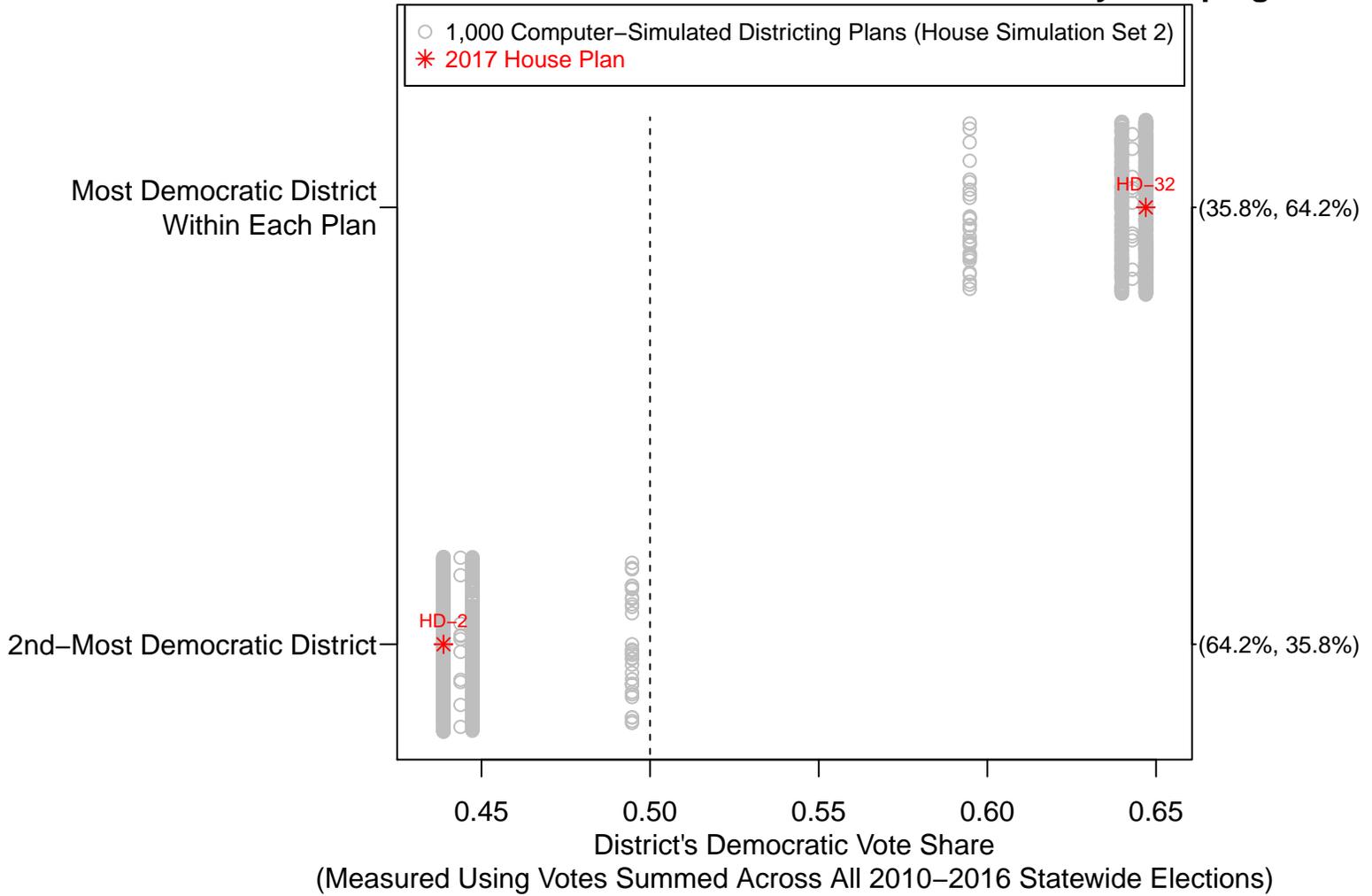
2017 Enacted House Plan Districts (12 Districts)

**Figure 44: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Lenoir-Pitt County Grouping**



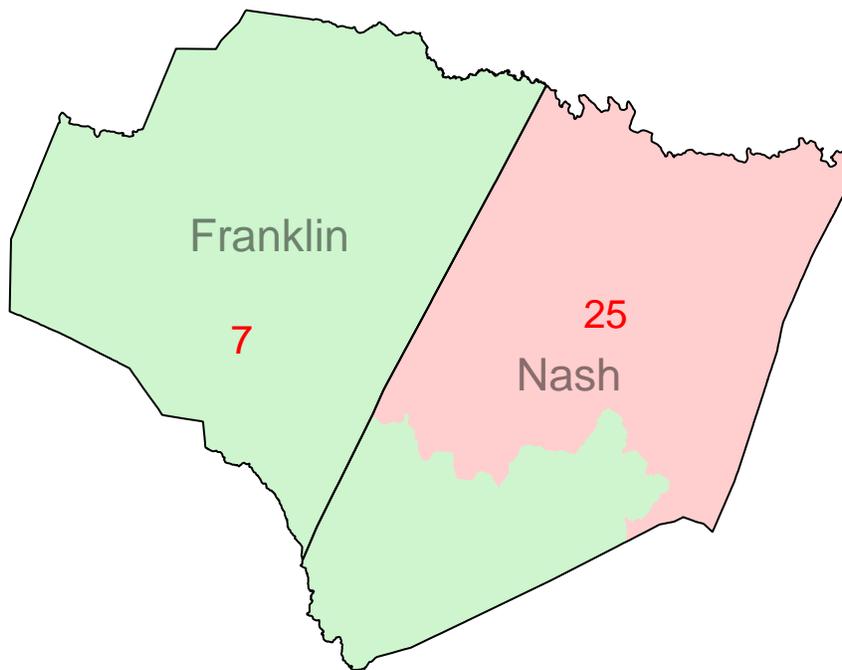
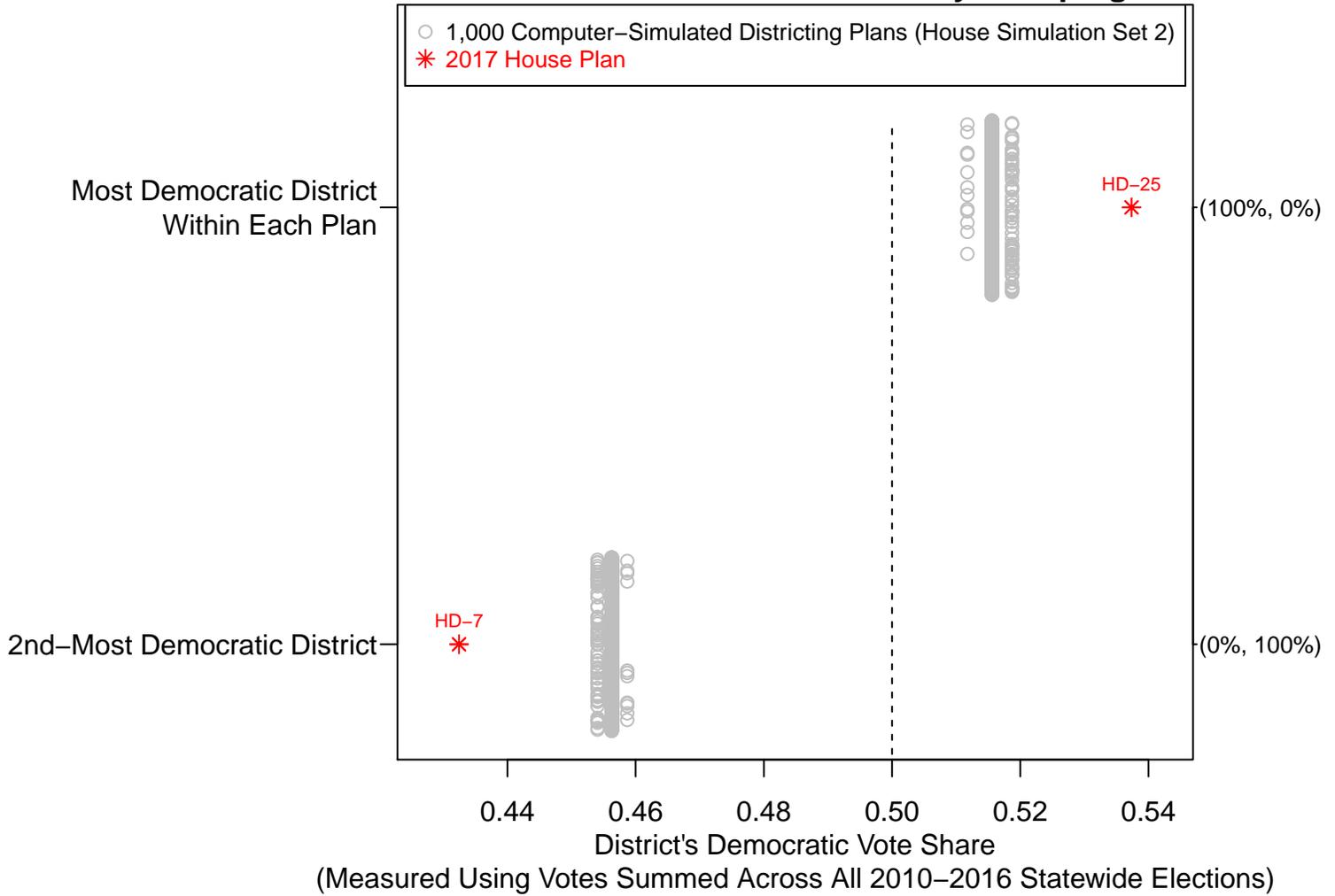
2017 Enacted House Plan Districts (3 Districts)

**Figure 45: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Granville–Person–Vance–Warren County Grouping**



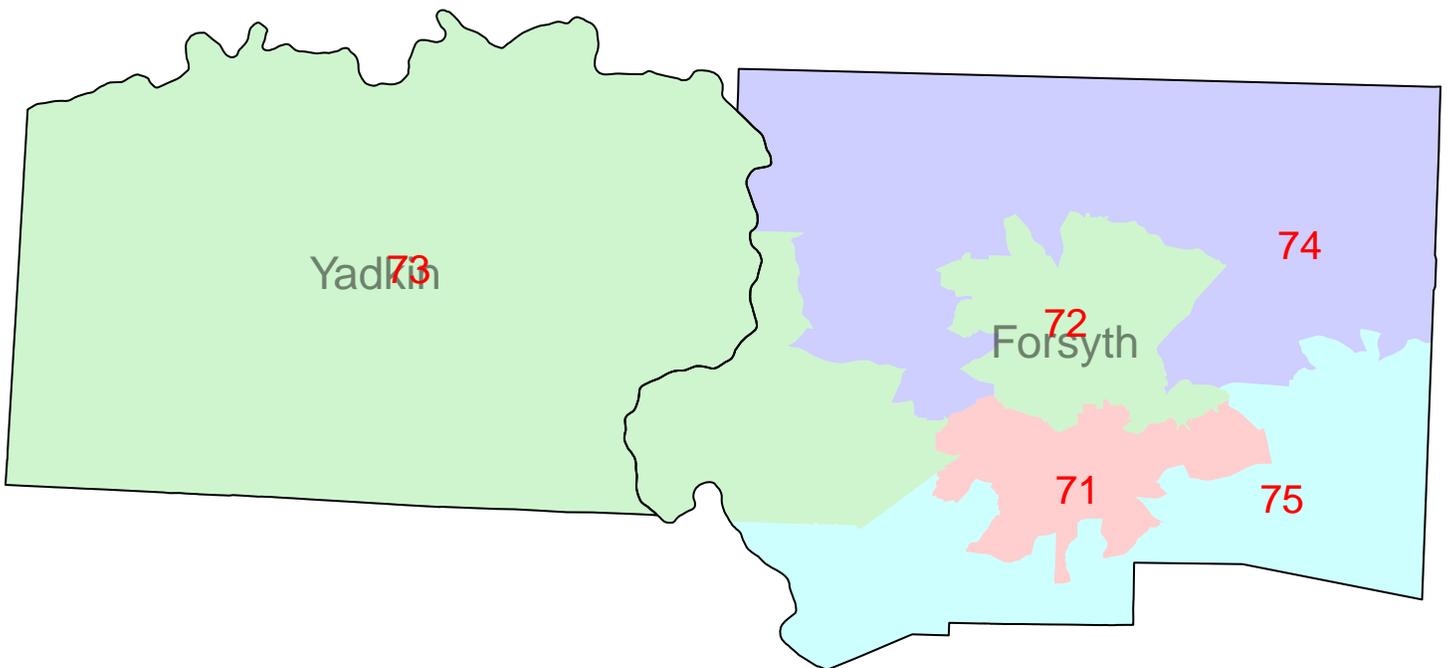
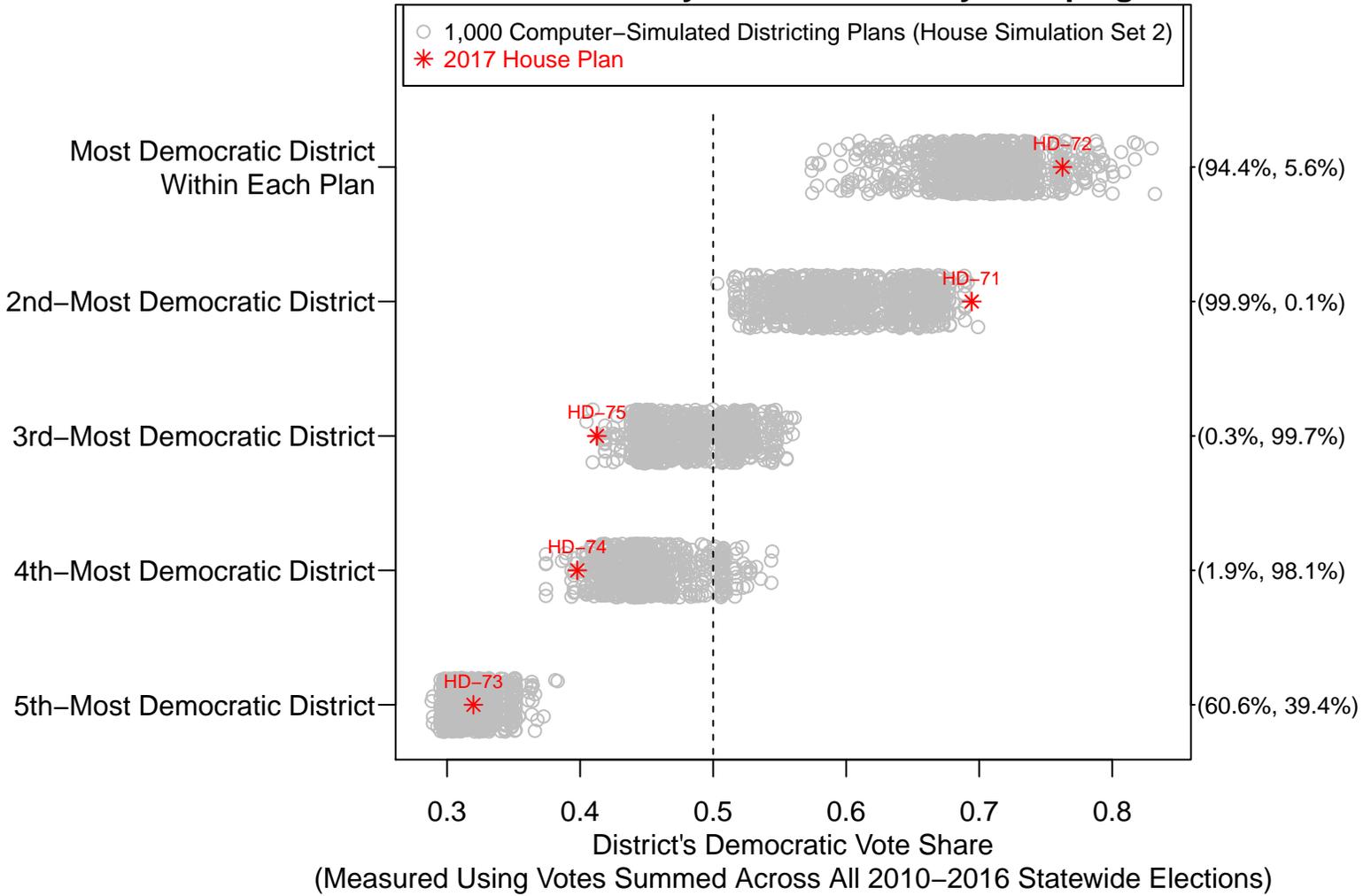
2017 Enacted House Plan Districts (2 Districts)

**Figure 46: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Franklin-Nash County Grouping**



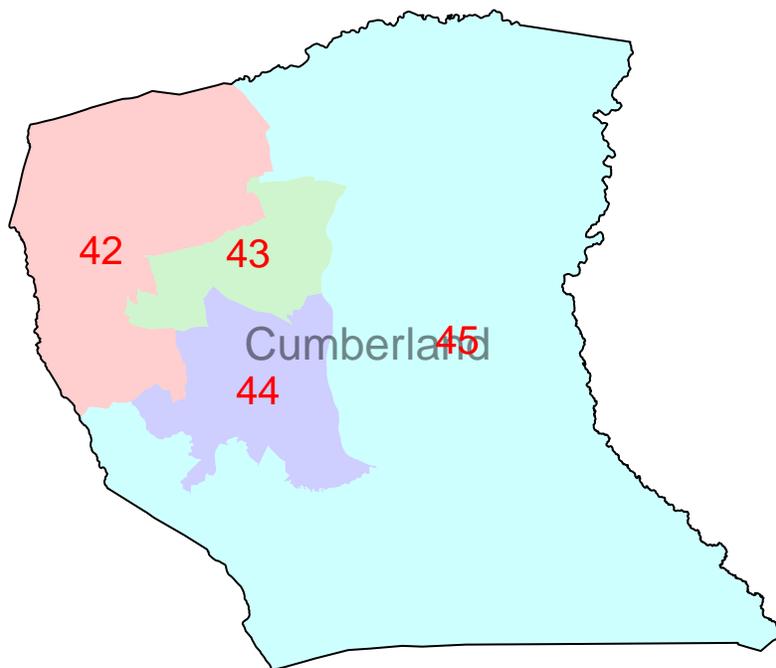
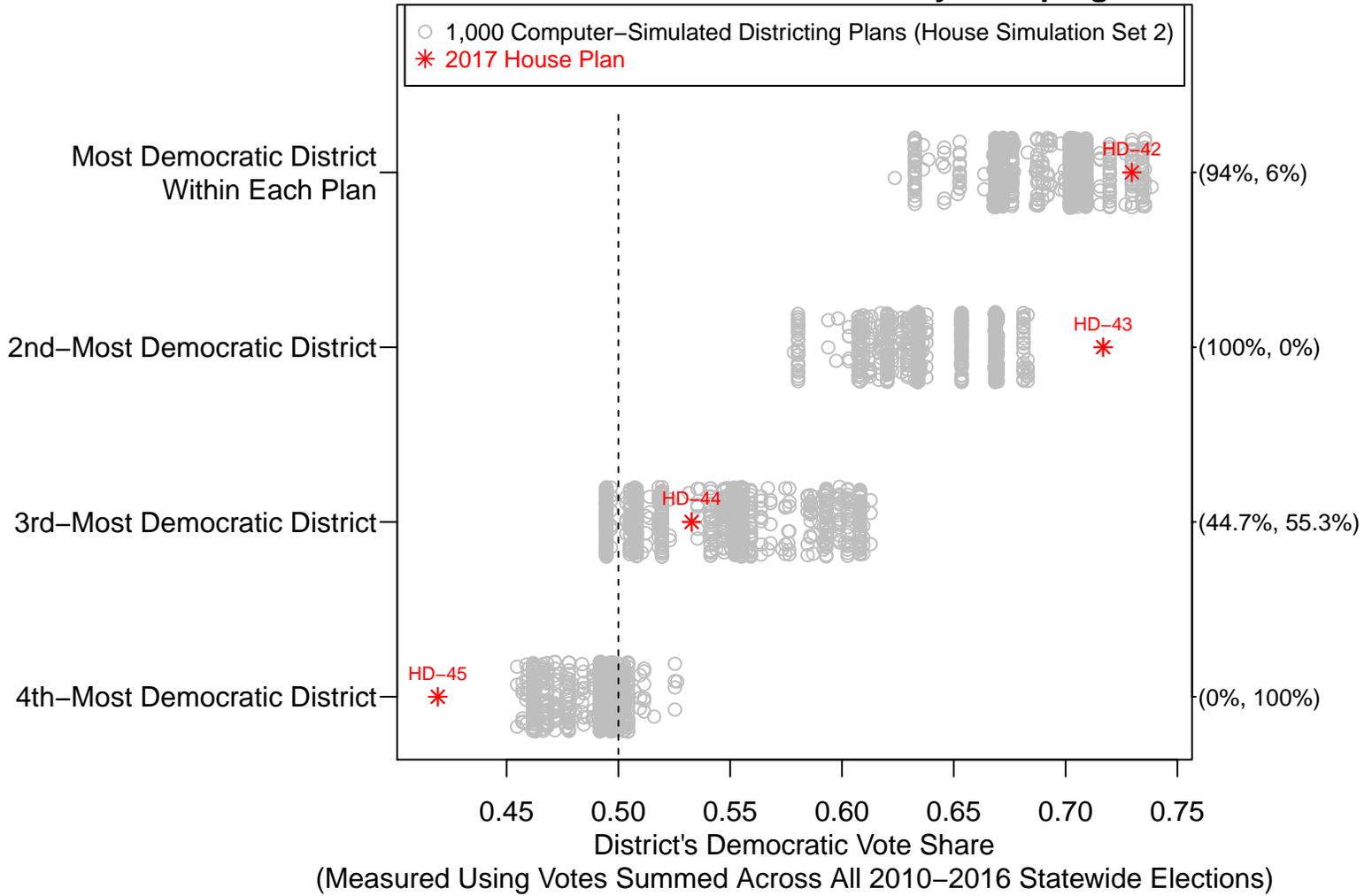
2017 Enacted House Plan Districts (2 Districts)

**Figure 47: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Forsyth–Yadkin County Grouping**



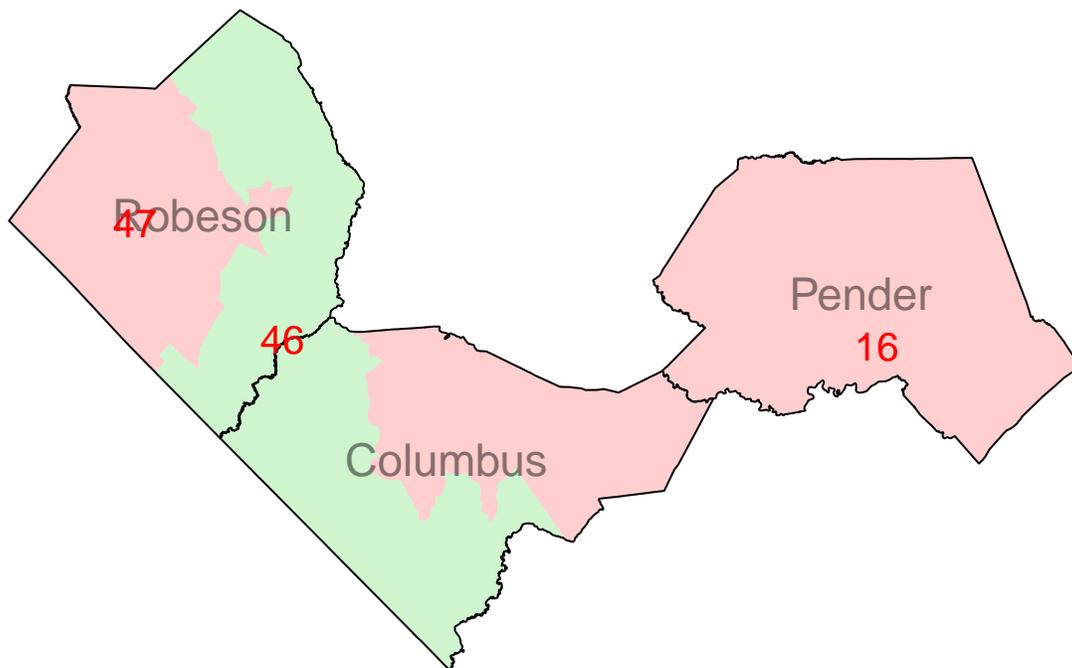
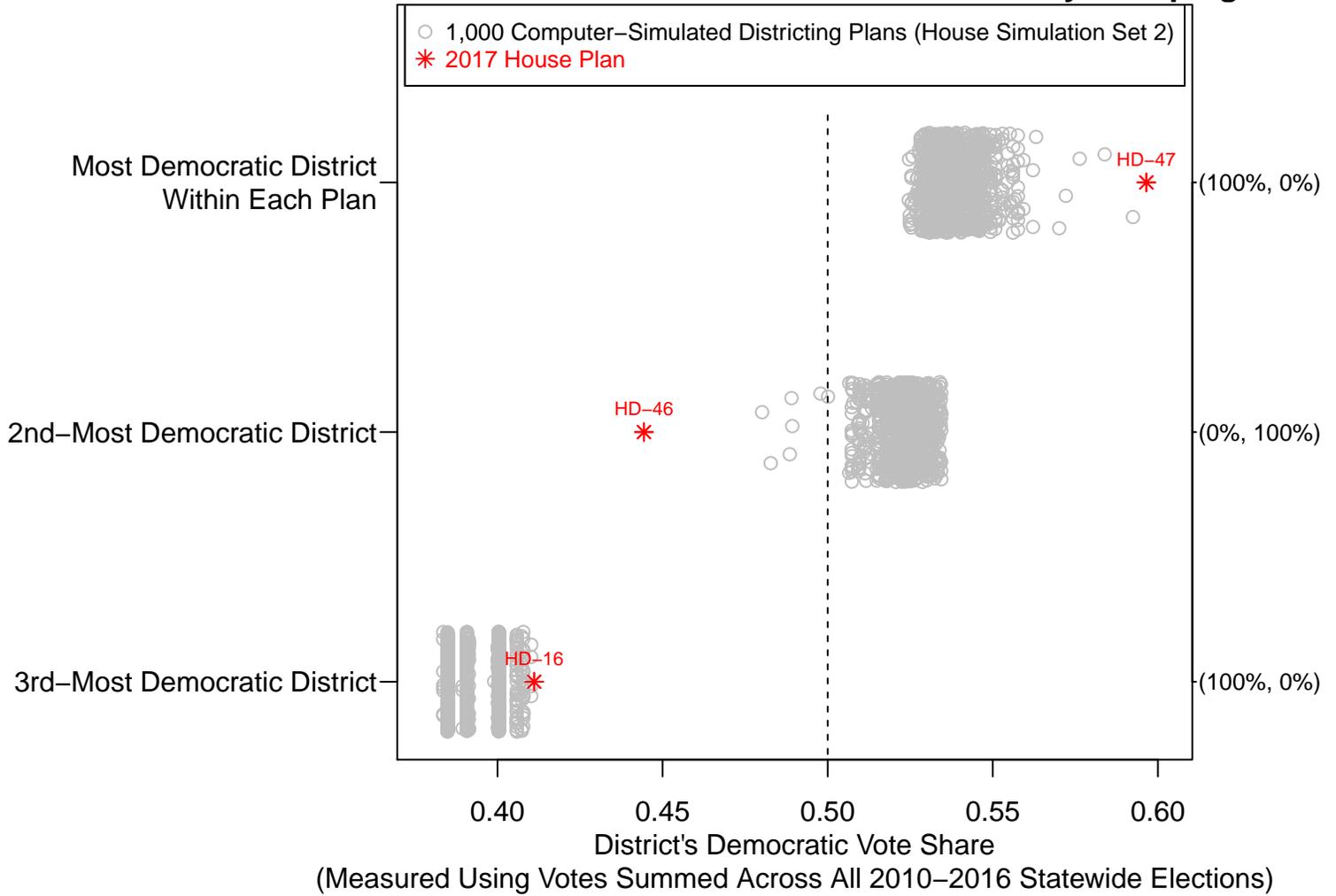
2017 Enacted House Plan Districts (5 Districts)

**Figure 48: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Cumberland County Grouping**



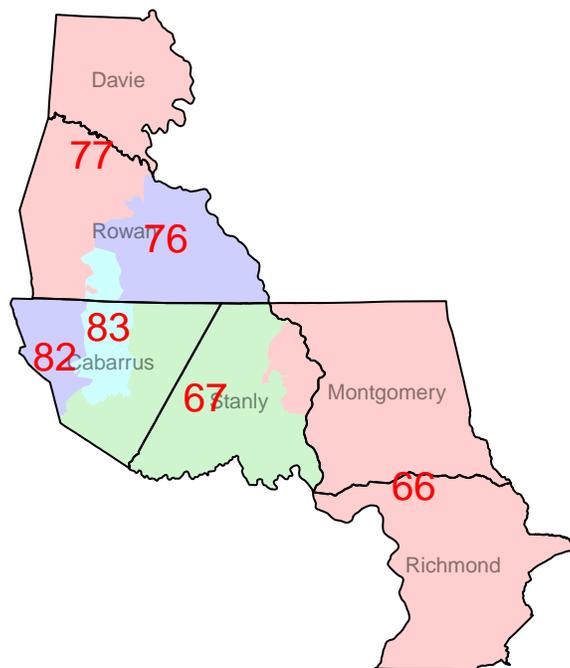
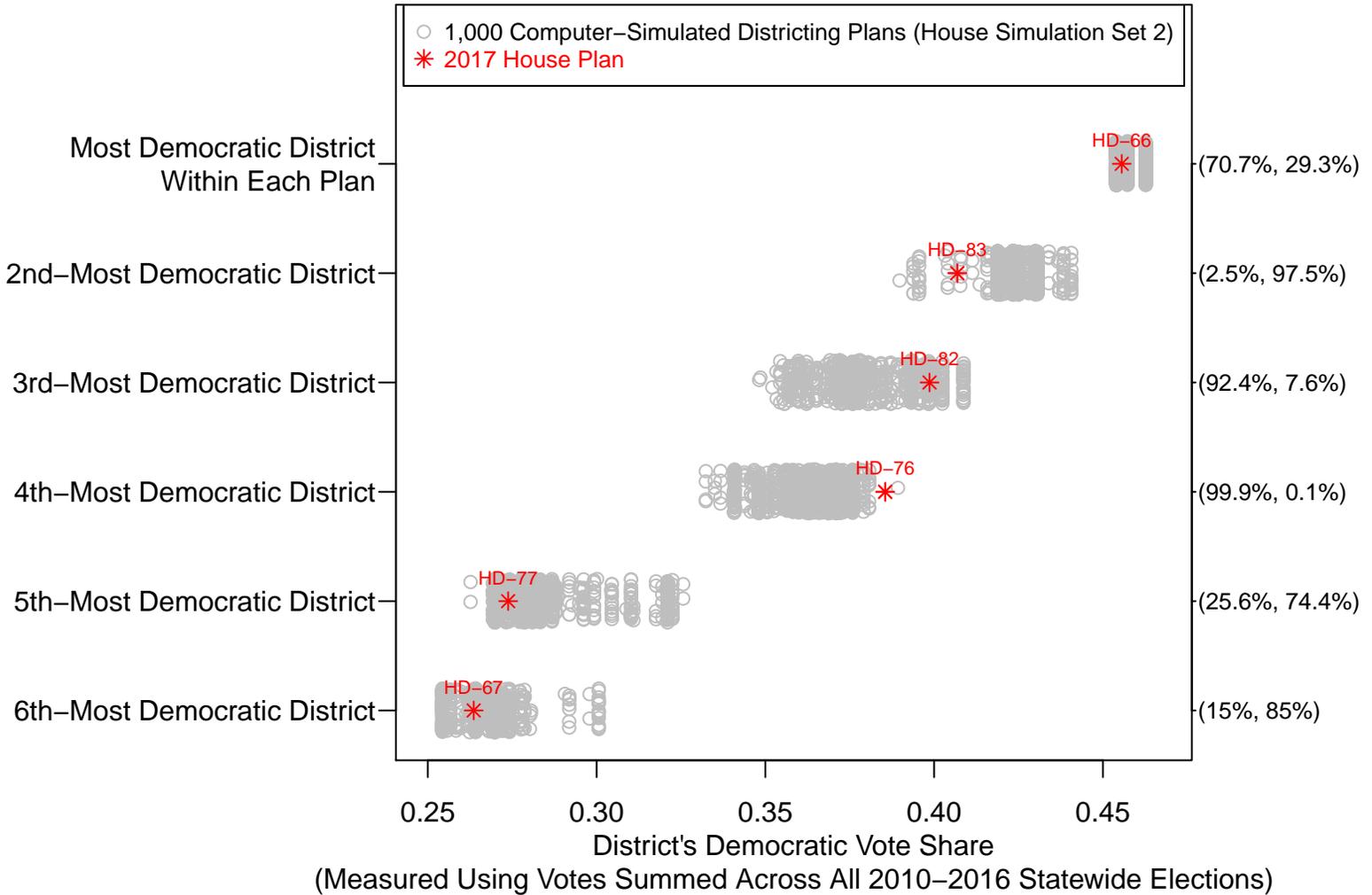
2017 Enacted House Plan Districts (4 Districts)

**Figure 49: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Columbus-Pender-Robeson County Grouping**



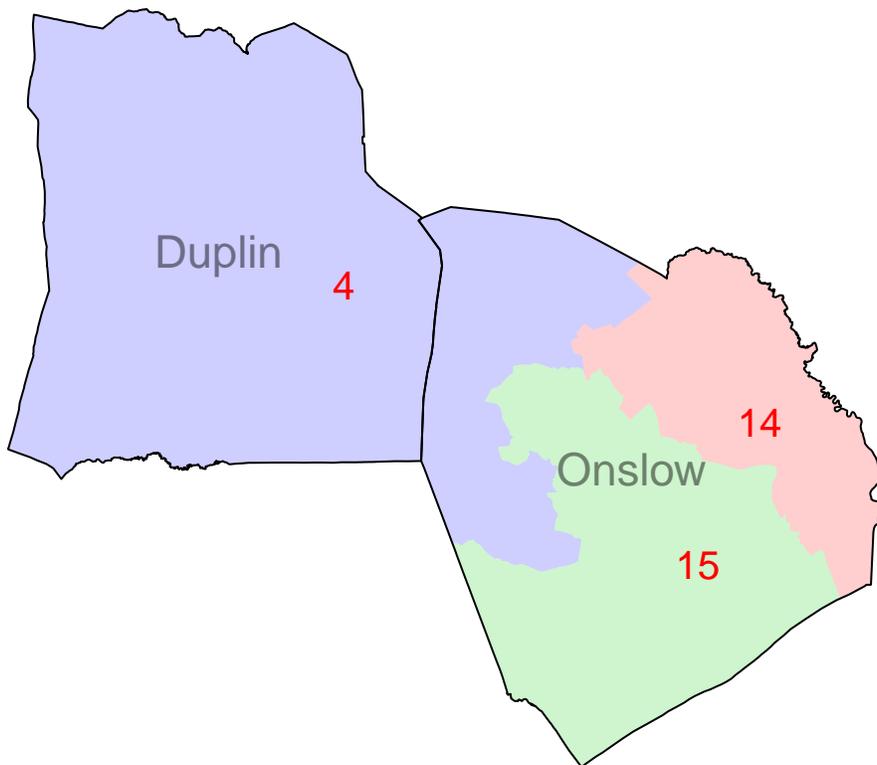
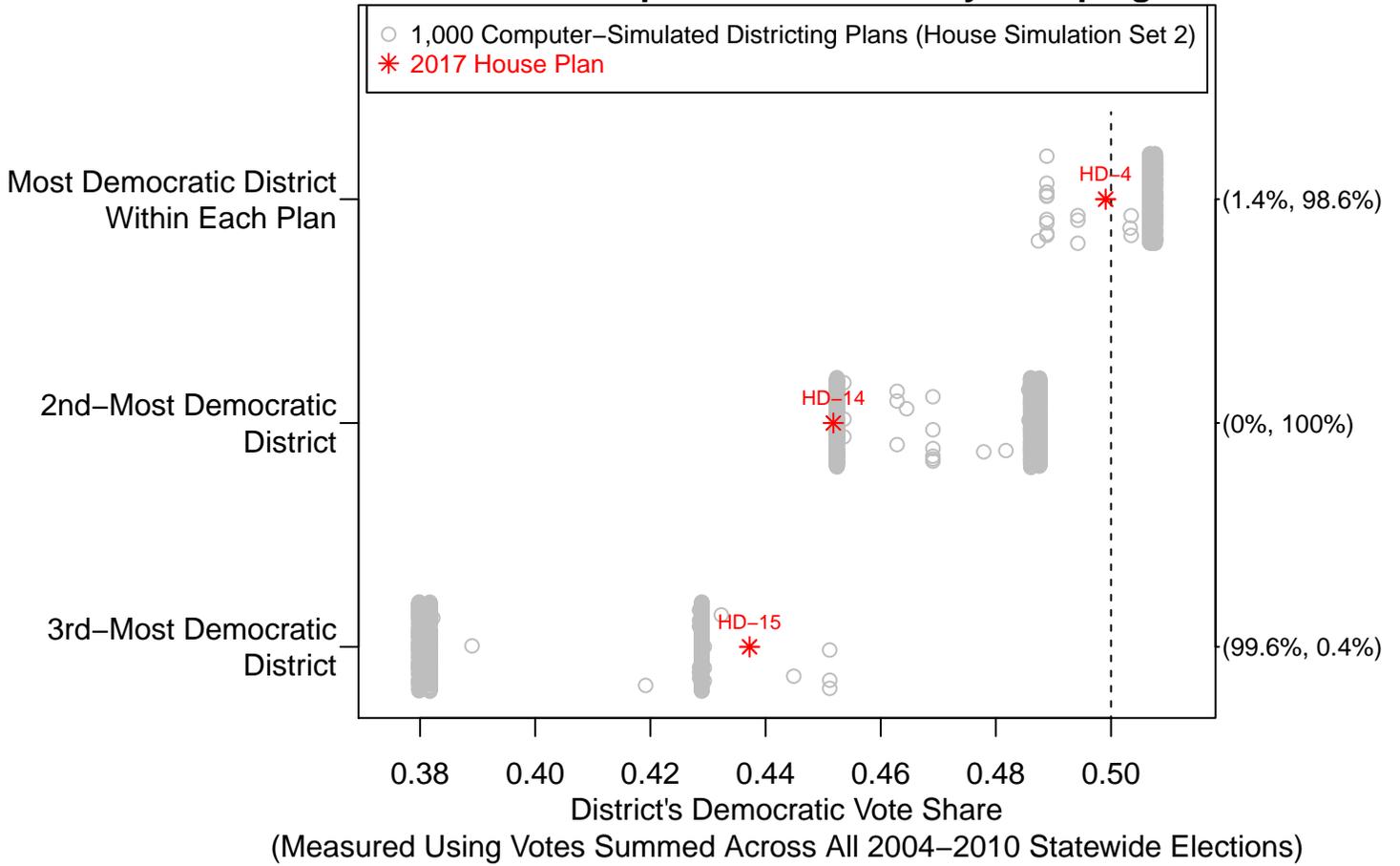
2017 Enacted House Plan Districts (3 Districts)

**Figure 50: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Cabarrus-Davie-Montgomery-Richmond-Rowan-Stanly County Grouping**



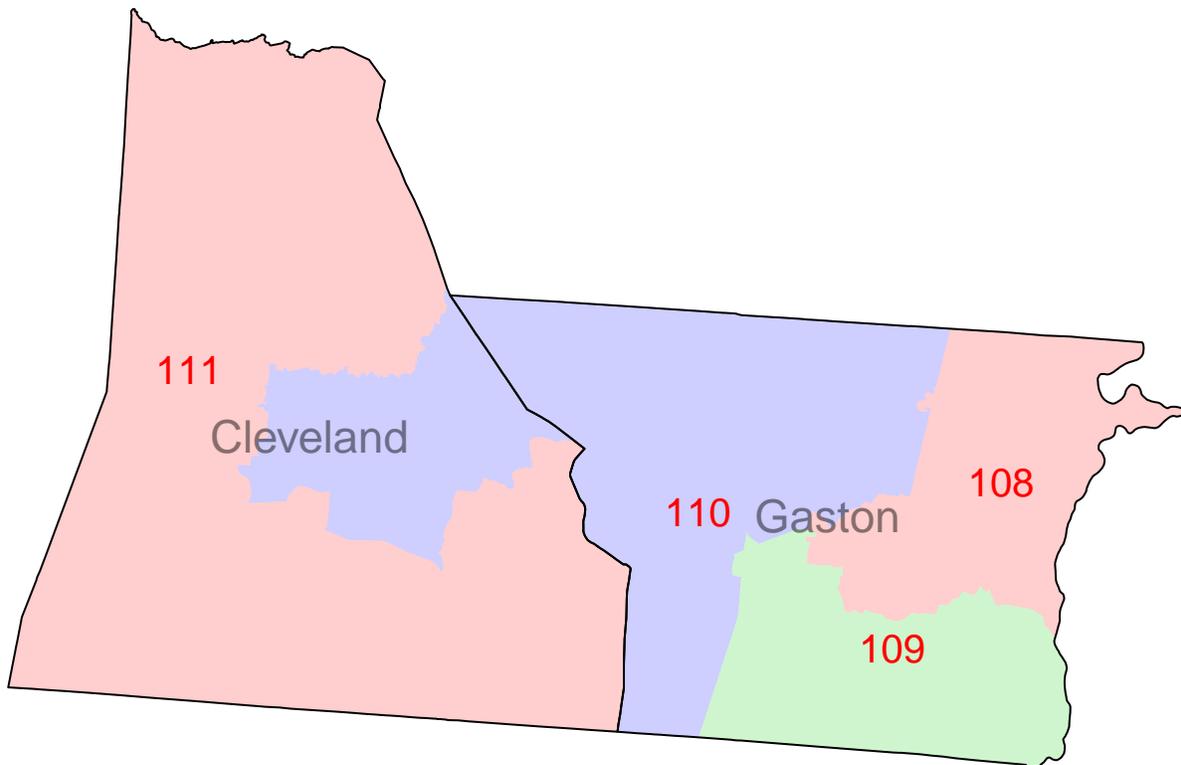
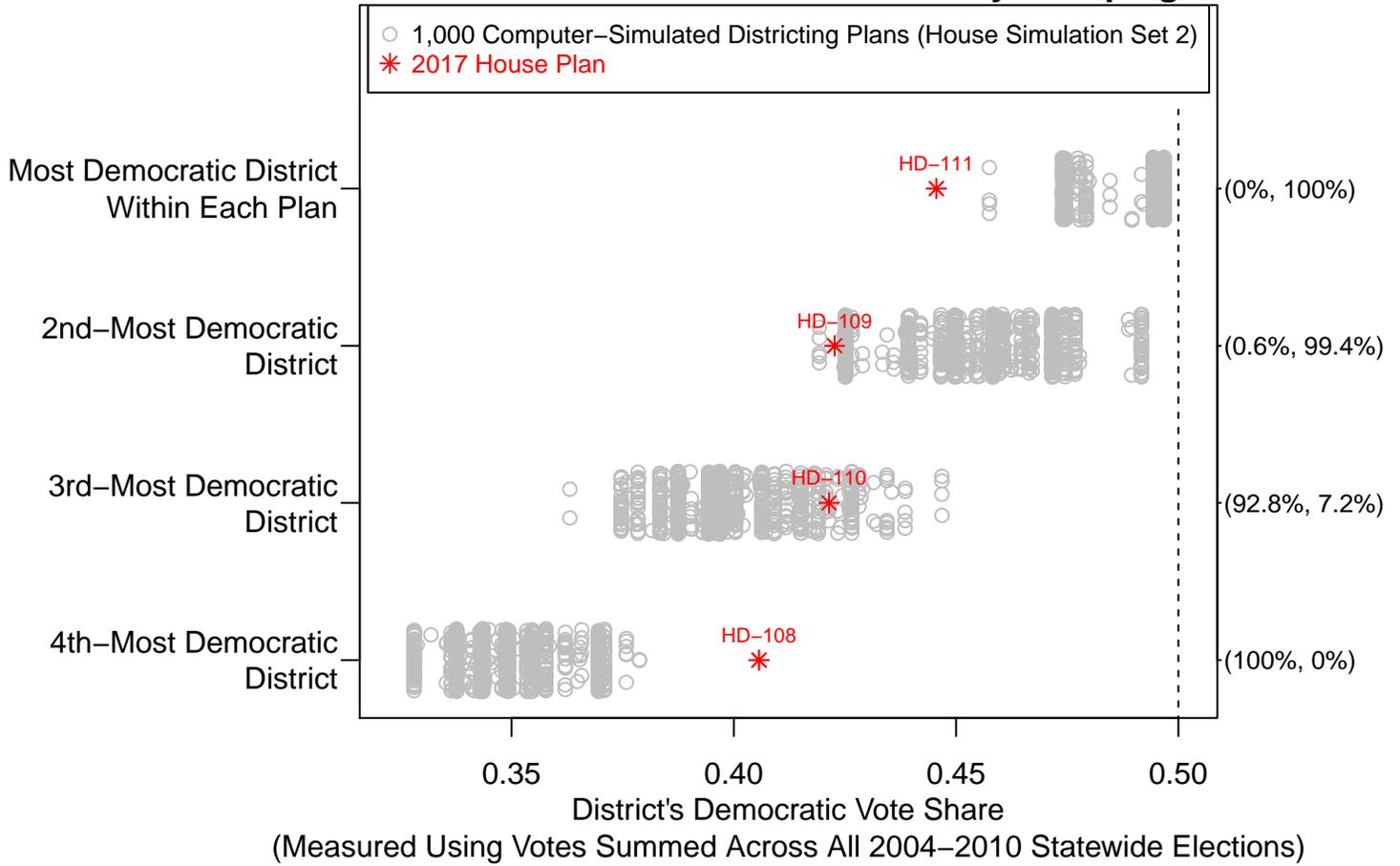
2017 Enacted House Plan Districts (6 Districts)

**Figure 51: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Duplin-Onslow County Grouping**



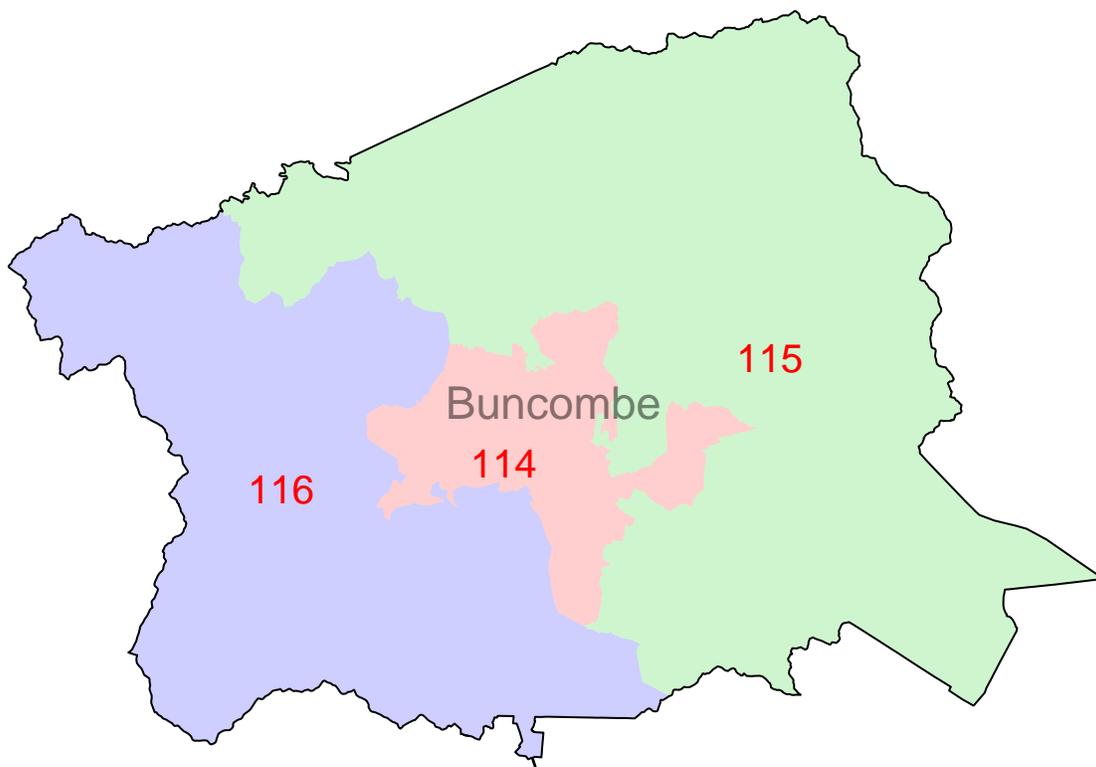
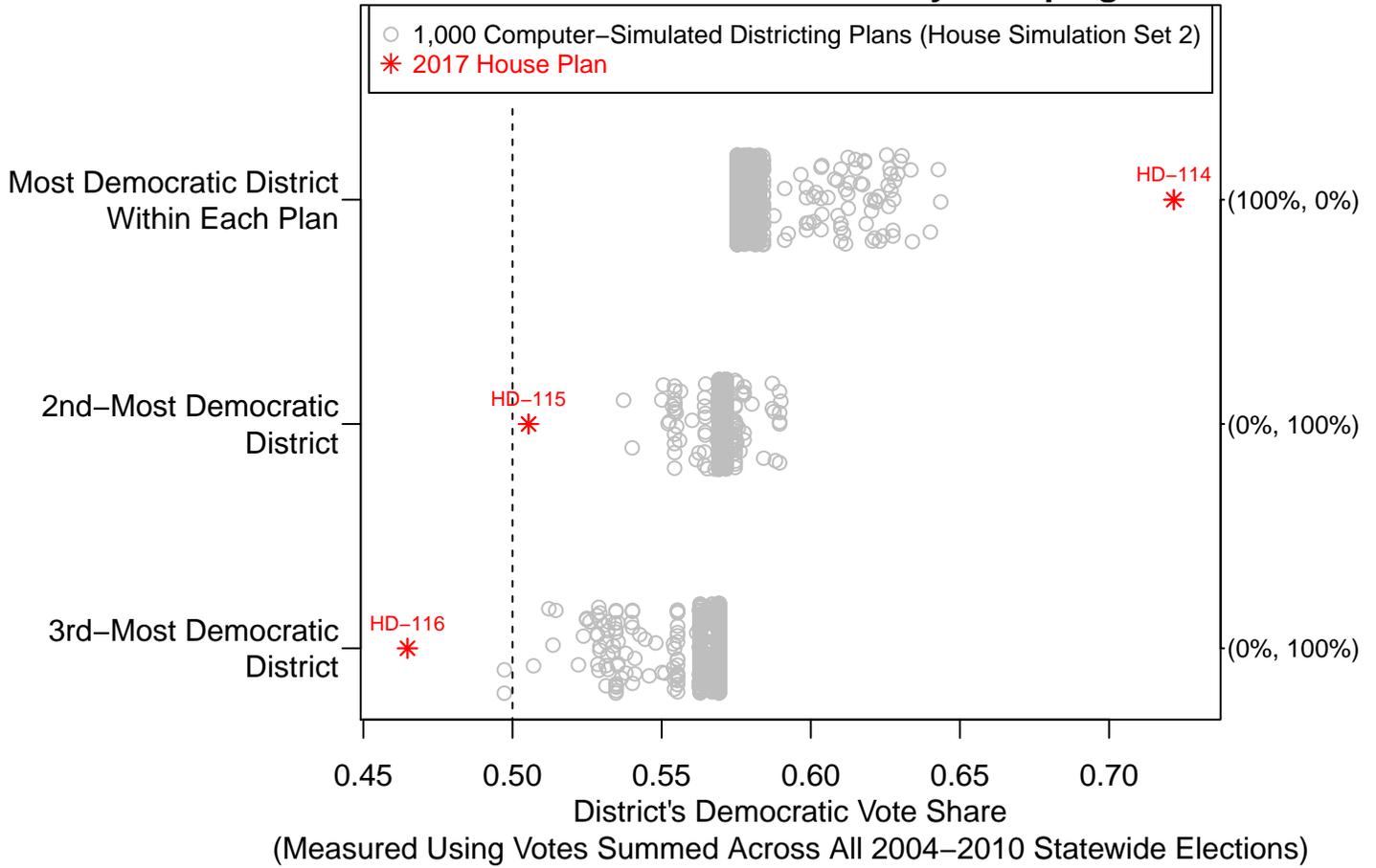
2017 Enacted House Plan Districts (3 Districts)

**Figure 52: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Cleveland-Gaston County Grouping**



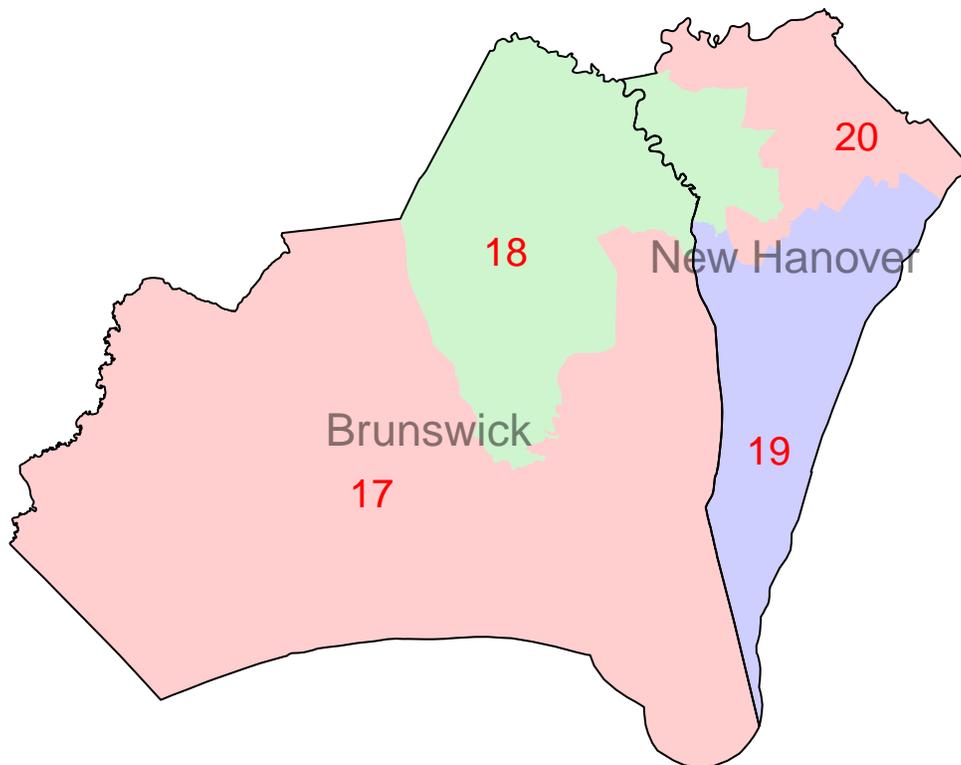
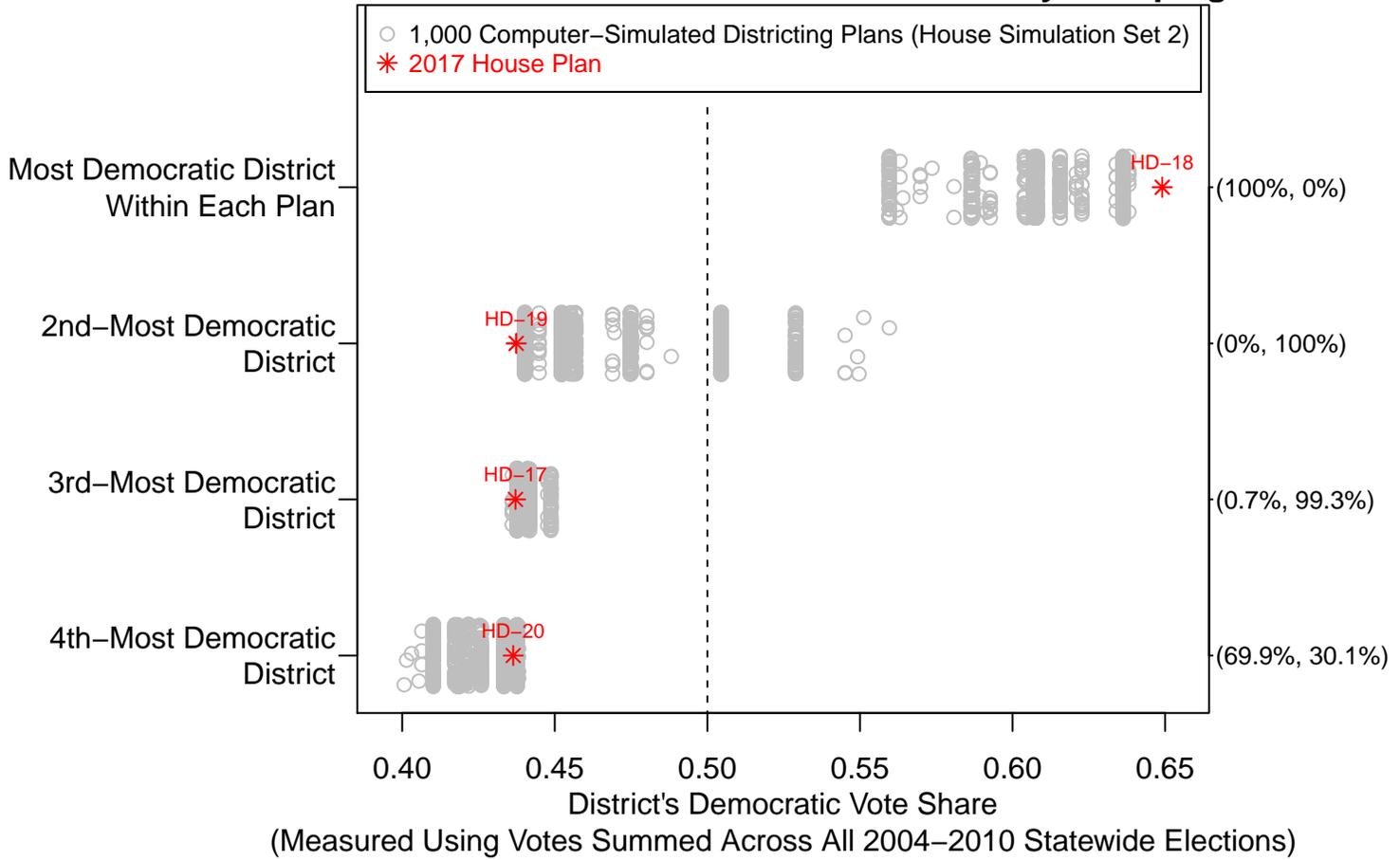
2017 Enacted House Plan Districts (4 Districts)

**Figure 53: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Buncombe County Grouping**



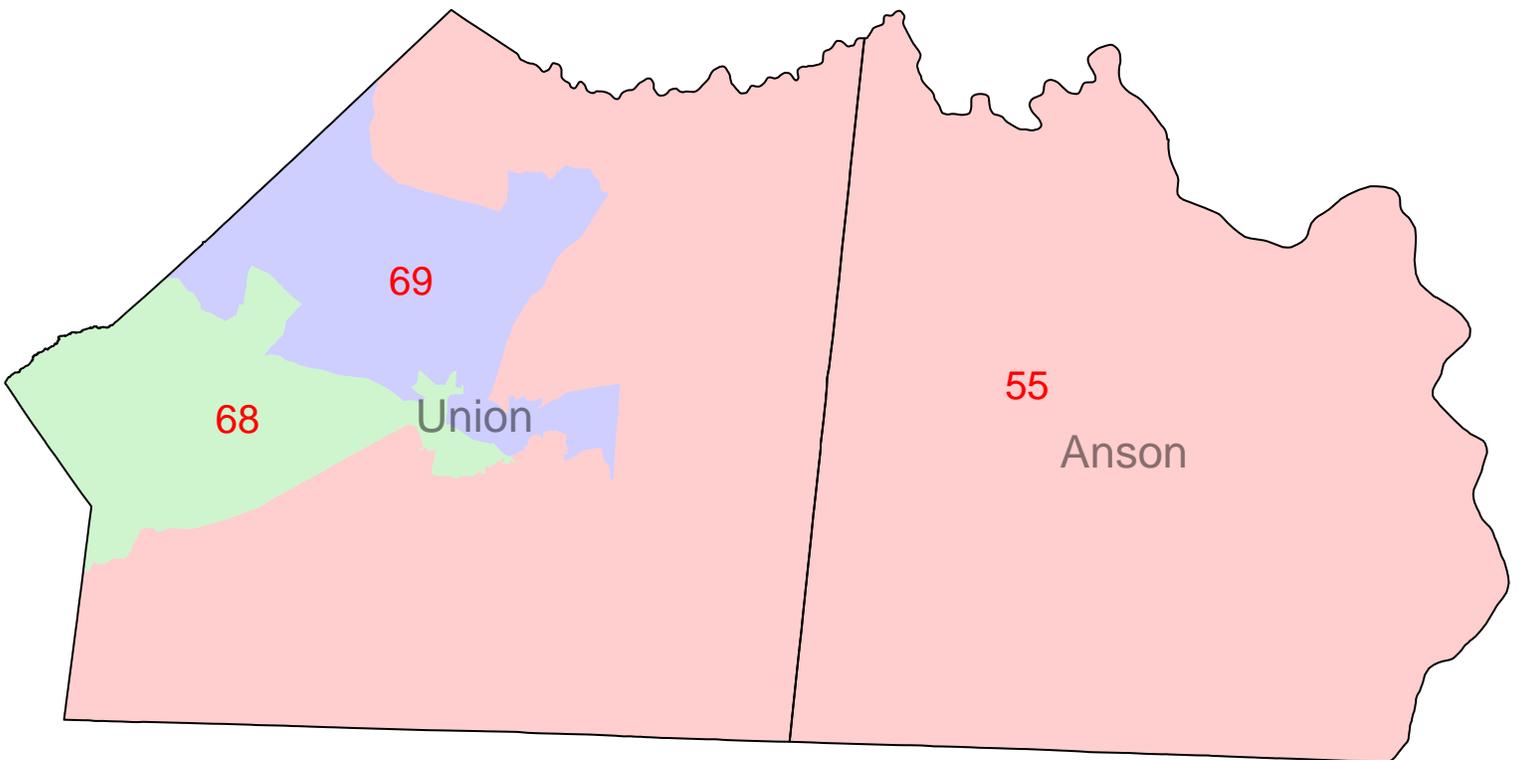
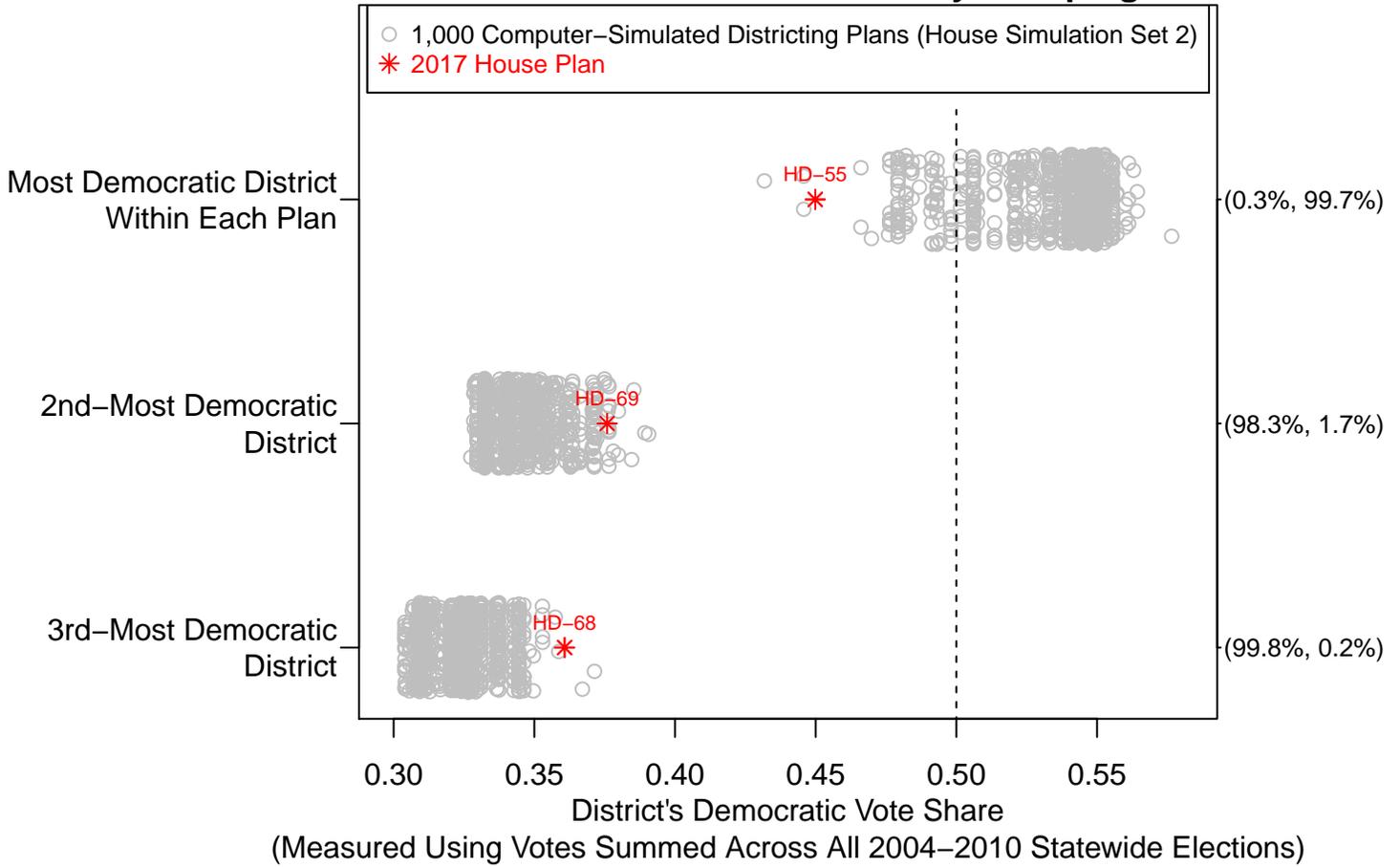
2017 Enacted House Plan Districts (3 Districts)

**Figure 54: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Brunswick–New Hanover County Grouping**



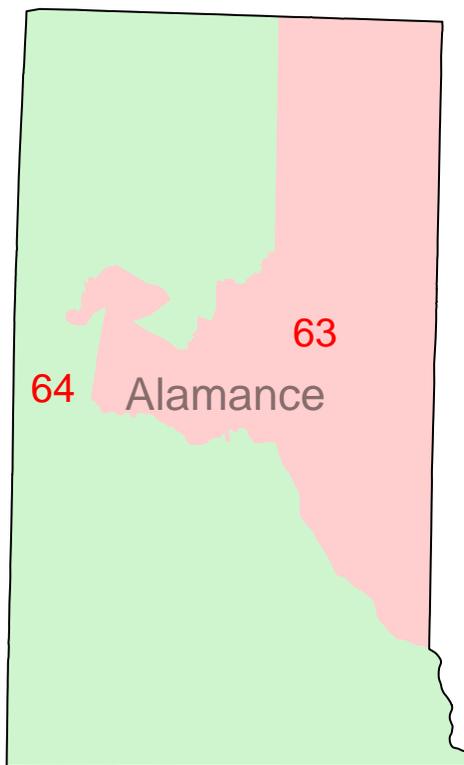
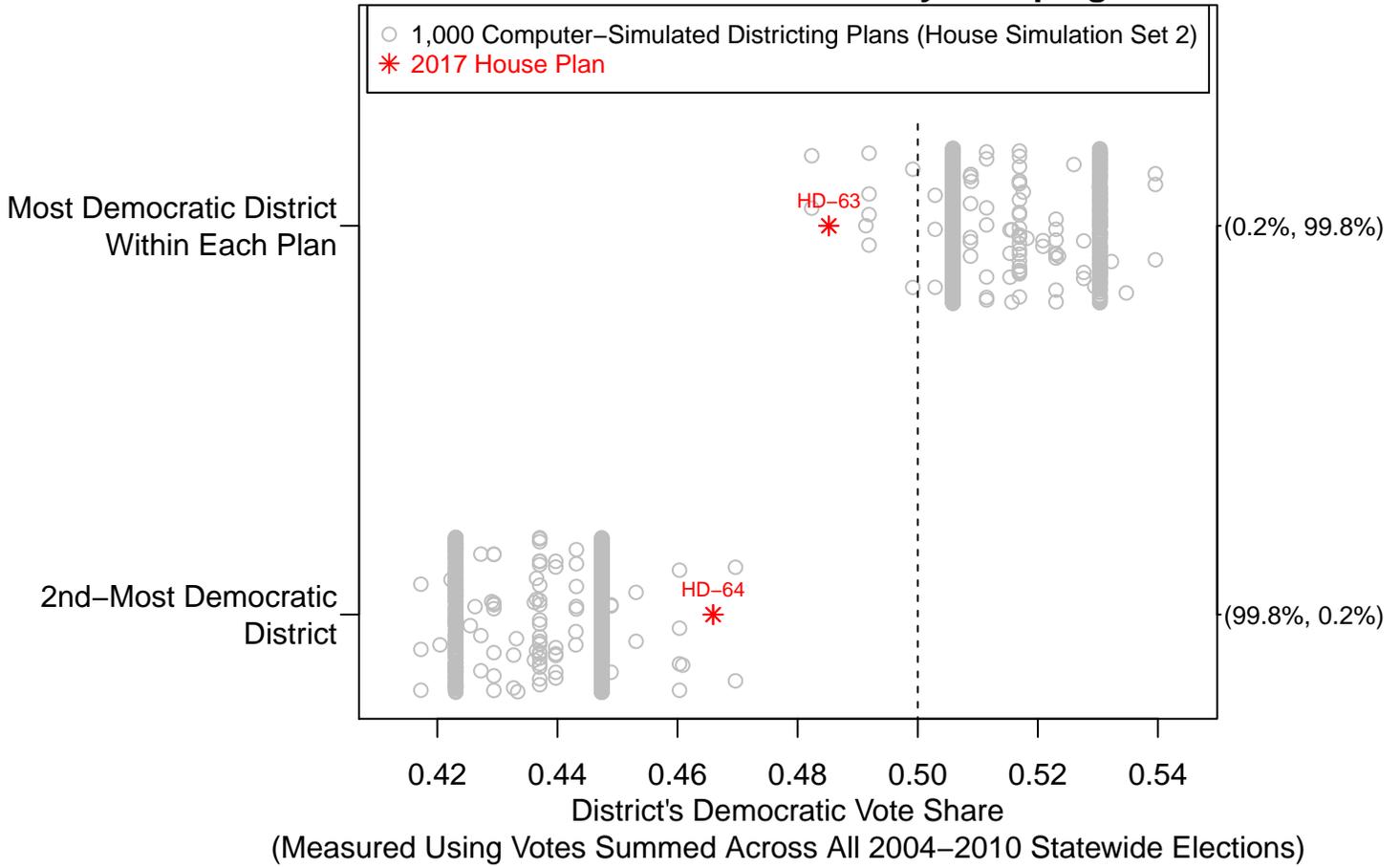
2017 Enacted House Plan Districts (4 Districts)

**Figure 55: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Anson-Union County Grouping**



2017 Enacted House Plan Districts (3 Districts)

**Figure 56: House Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Alamance County Grouping**



2017 Enacted House Plan Districts (2 Districts)

Comparing the Number of Threshold-Level Republican Districts in the Enacted and Simulated Plans: The second approach I use is as follows: Within each county grouping, I consider all of the 2017 House Plan districts in the grouping that are Republican-leaning (with over a 50% Republican vote share), and I identify the most minimally Republican-leaning of these enacted districts. For both the 2017 House Plan and each of the computer-simulated plans, I then compare the number of districts within the grouping that are at least as Republican-leaning as the most minimally Republican-leaning district within that grouping in the 2017 House Plan.

For each grouping in the 2017 House Plan, the most minimally Republican-leaning district is the district with the lowest Republican vote share that is still above 50%. In other words, this approach is asking: Within a particular county grouping, how many districts does each plan create that are as Republican-leaning as the 2017 House Plan's least-Republican-leaning district within the grouping? The intuition of this approach is to measure the extent to which the 2017 House Plan attempted to maximize the total number of Republican-leaning districts in the grouping that had at least as much "cushion" as the most minimally-Republican-leaning district in that grouping.

Figure 59 illustrates an example of this approach, analyzing the Columbus, Pender, and Robeson County grouping in the 2017 House Plan, which contains three districts (HD 16, HD-46, and HD-47). Two of these three districts are Republican-leaning, as measured using the 2010-2016 Statewide Election Composite. Among these two Republican-leaning districts, HD-46, with a Republican vote share of 55.56%, is the most minimally Republican-leaning of these districts. Therefore, I use this 55.56% Republican vote share threshold, and I count the number of districts in the 2017 House Plan and in the computer-simulated plans within this county grouping that are at least as heavily Republican as HD-46's Republican vote share of 55.56%.

The two histograms in Figure 59 illustrate the results of this analysis of the Columbus, Pender, and Robeson County grouping. The 2017 House Plan contains two districts (HD-46 and HD-16) that are at least as Republican as HD-46's Republican vote share of 55.56%. The left histogram in Figure 59 reveals that every single one of the 1,000 simulated plans in House Simulation Set 1 contains only one district in this county grouping with at least a 55.56% Republican vote share. Similarly, the right histogram in Figure 59 also illustrates that every one of the 1,000 simulated plans in House Simulation Set 2 contains only one district in this county grouping with at least a 55.56% Republican vote share. Not a single one of these 2,000

computer-simulated plans contains two such Republican districts. Therefore, the 2017 House Plan is a statistical outlier within the Columbus-Pender-Robeson County grouping in its creation of two Republican districts with at least a 55.56% Republican vote share.

I use this same approach to analyze each 2017 House Plan district within different county groupings. Figures 57 to 73 each focus on a single county grouping, with the left histogram analyzing House Simulation Set 1 plans and the right histogram analyzing House Simulation Set 2. As before, for county groupings containing districts that were originally drawn in 2011 and remained unchanged in the 2017 redistricting process, I used the 2004-2010 Statewide Election Composite to measure district partisanship in these Figures, since the 2004-2010 statewide elections represent the elections data available to and used by the General Assembly during the 2011 redistricting process. Finally, in the Guilford County grouping (Figure 64), which contains six total districts, note that three of the 2017 House Plan districts within Guilford County were materially redrawn by Special Master Nathaniel Persily and are frozen in all simulated plans in House Simulation Set 1 and Set 2. Therefore, these Special Master districts are not included in my analysis of the Guilford County grouping. Instead, Figure 64 shows results only for the three other districts that are not frozen across all simulated plans (HD-58, HD-59, and HD-60).

For the Cabarrus, Davie, Montgomery, Richmond, Rowan, and Stanly County grouping, I found that the least-Republican-leaning district (HD-66) generally has little geographic variation across the 2,000 simulated House plans and the 2017 House Plan. Because of the long, narrow geographic shape of this county grouping, the least-Republican-leaning district generally lies at the southern end of this grouping, covering all of Richmond and Montgomery Counties and a small, eastern portion of Stanly County. As a result, this least-Republican-leaning district exhibits little partisan variation across the 2,000 House simulations and the 2017 House Plan.

Therefore, for the Cabarrus, Davie, Montgomery, Richmond, Rowan, and Stanly County grouping, I performed the following additional analysis: In Figure 57, I first analyzed the number of districts in the grouping that are at least as Republican as the least-Republican-leaning district in the 2017 House Plan (HD-66). And then in Figure 58, I analyzed the number of districts in the grouping that are at least as Republican as the second-least-Republican-leaning district in the 2017 House Plan (HD-83, which contains a Republican vote share of 59.31%). Figure 58 illustrates that the 2017 House Plan contains five such districts (HD-67, HD-76, HD-77, HD-82, and HD-83), while over 95% of the simulated plans in House Simulation Set 1 and Set 2 contain

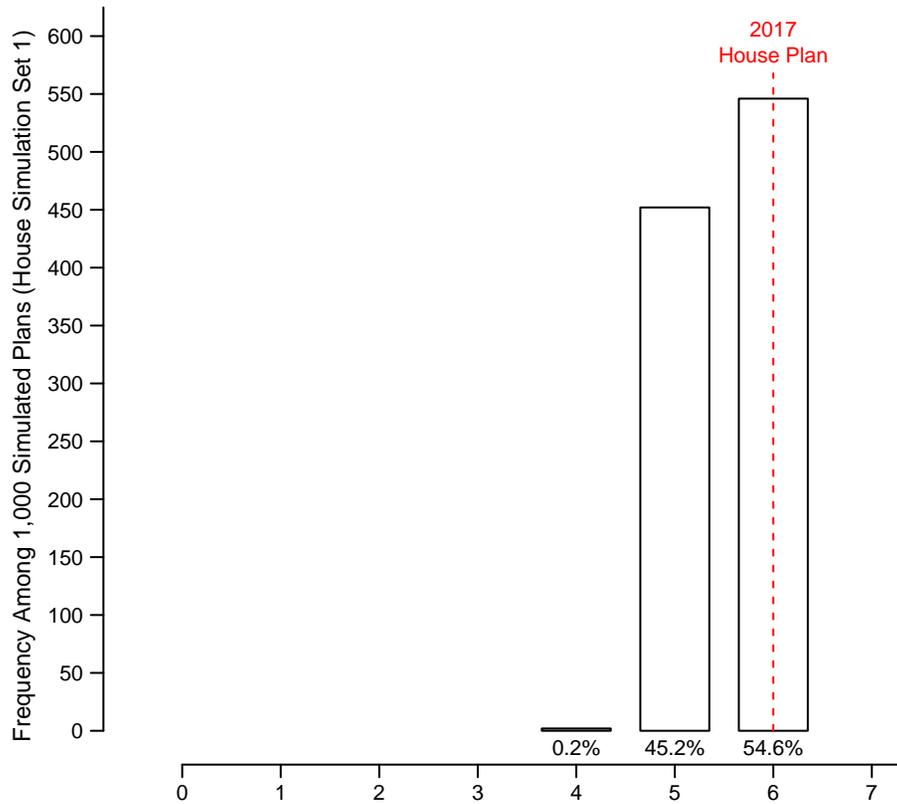
only three or four such Republican districts. Thus, I found that the 2017 House Plan is a statistical outlier in its creation of five Republican-leaning districts with a vote share of at least 59.31%.

Overall, using this partisan threshold methodology, I found that the 2017 House plan creates partisan outliers within the following 14 House county groupings:

1. The Alamance County grouping (Figure 68).
2. The Anson-Union County grouping (Figure 69).
3. The Brunswick-New Hanover County grouping (Figure 70).
4. The Buncombe County grouping (Figure 71).
5. The Cabarrus-Davie-Montgomery-Richmond-Rowan-Stanly County grouping (Figure 58).
6. The Cleveland-Gaston County grouping (Figure 72).
7. The Columbus-Pender- Robeson County grouping (Figure 59).
8. The Cumberland County grouping (Figure 60).
9. The Duplin-Onslow County grouping (Figure 73).
10. The Forsyth-Yadkin County grouping (Figure 61).
11. The Franklin-Nash County grouping (Figure 62).
12. The Guilford County grouping (Figure 64).
13. The Mecklenburg County grouping (Figure 66).
14. The Wake County grouping (Figure 67).

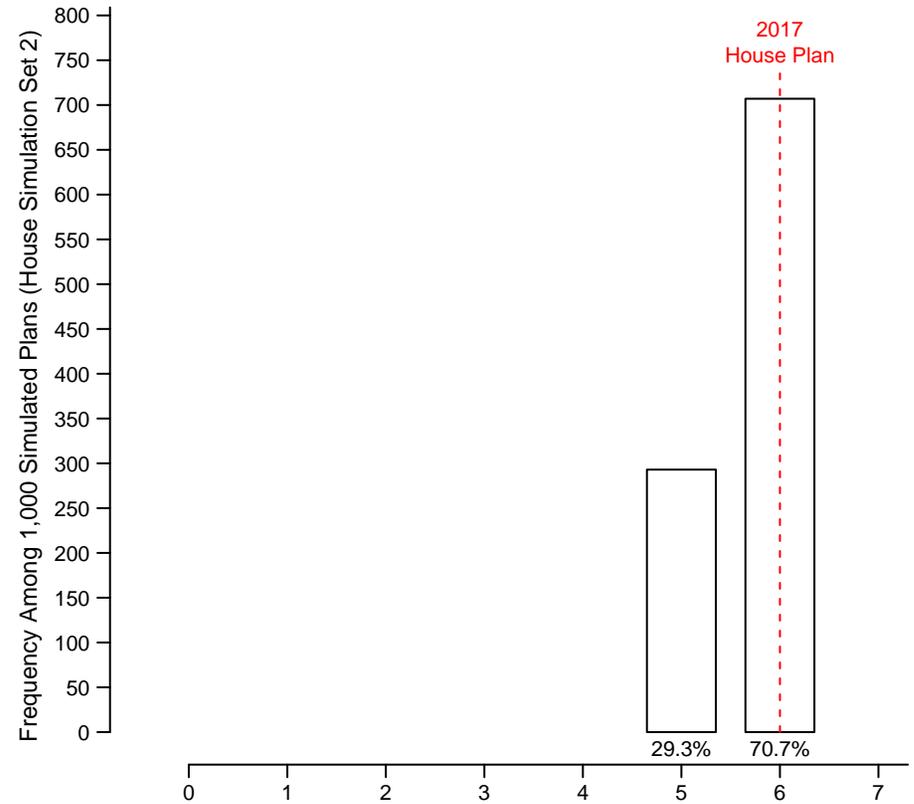
**Figure 57:
Number of House Districts With At Least HD-66's Republican Vote Share of 54.44% in the
Cabarrus–Davie–Montgomery–Richmond–Rowan–Stanly County Grouping**

Simulation Set 1



Number of Districts With At Least HD-66's Republican Vote Share of 54.44% in the Cabarrus–Davie–Montgomery–Richmond–Rowan–Stanly County Grouping (Measured Using Votes Summed Across 2010–2016 Statewide Elections)

Simulation Set 2

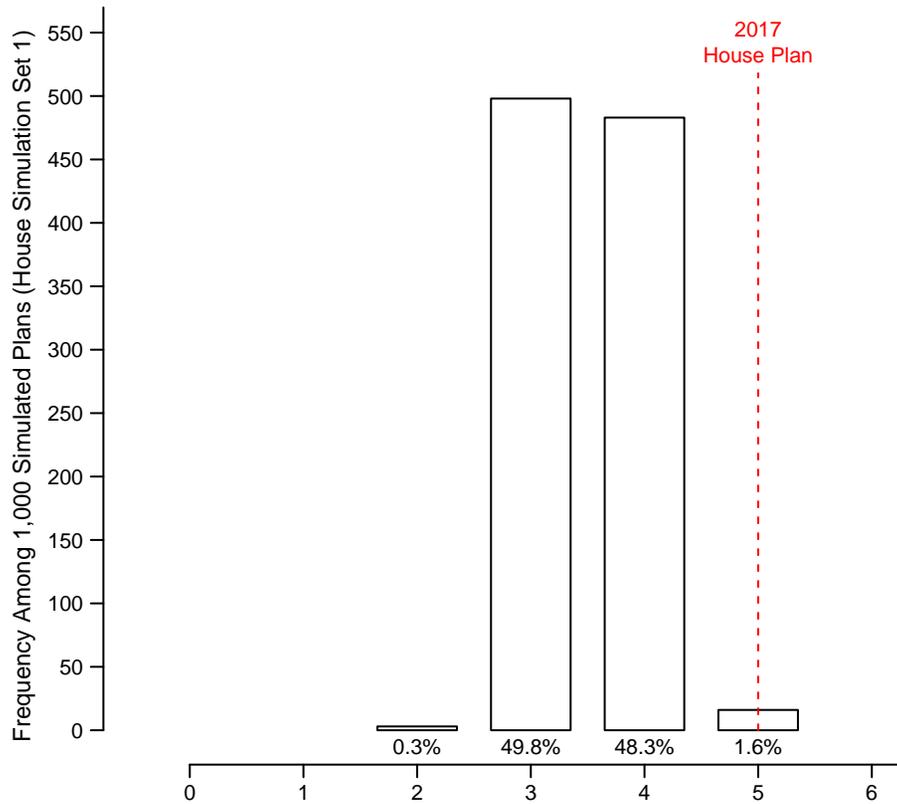


Number of Districts With At Least HD-66's Republican Vote Share of 54.44% in the Cabarrus–Davie–Montgomery–Richmond–Rowan–Stanly County Grouping (Measured Using Votes Summed Across 2010–2016 Statewide Elections)

Note: The Cabarrus–Davie–Montgomery–Richmond–Rowan–Stanly County Grouping includes the following 2017 House Plan districts: 66; 67; 76; 77; 82; 83

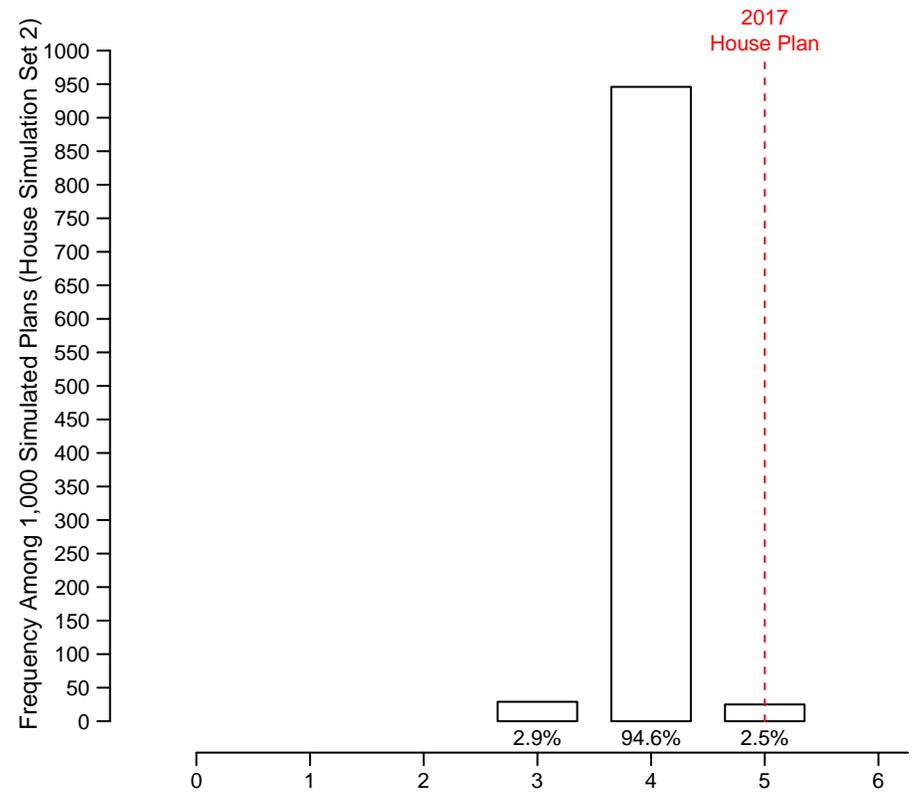
**Figure 58:
Number of House Districts With At Least HD-83's Republican Vote Share of 59.31% in the
Cabarrus–Davie–Montgomery–Richmond–Rowan–Stanly County Grouping**

Simulation Set 1



Number of Districts With At Least HD-83's Republican Vote Share of 59.31% in the Cabarrus–Davie–Montgomery–Richmond–Rowan–Stanly County Grouping (Measured Using Votes Summed Across 2010–2016 Statewide Elections)

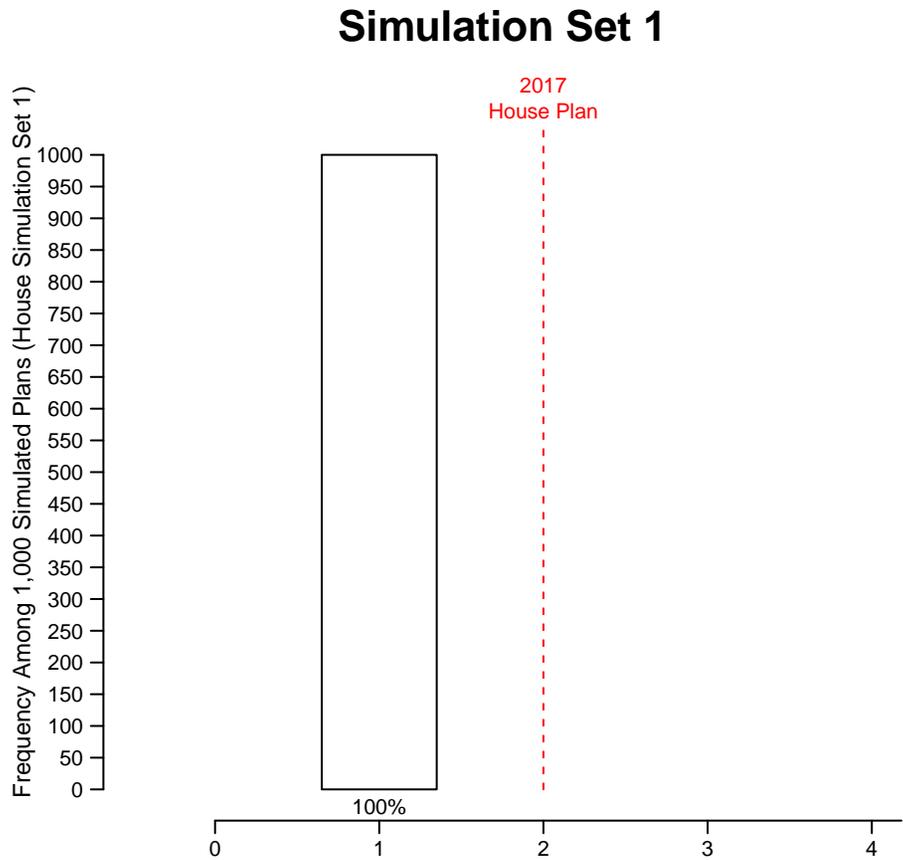
Simulation Set 2



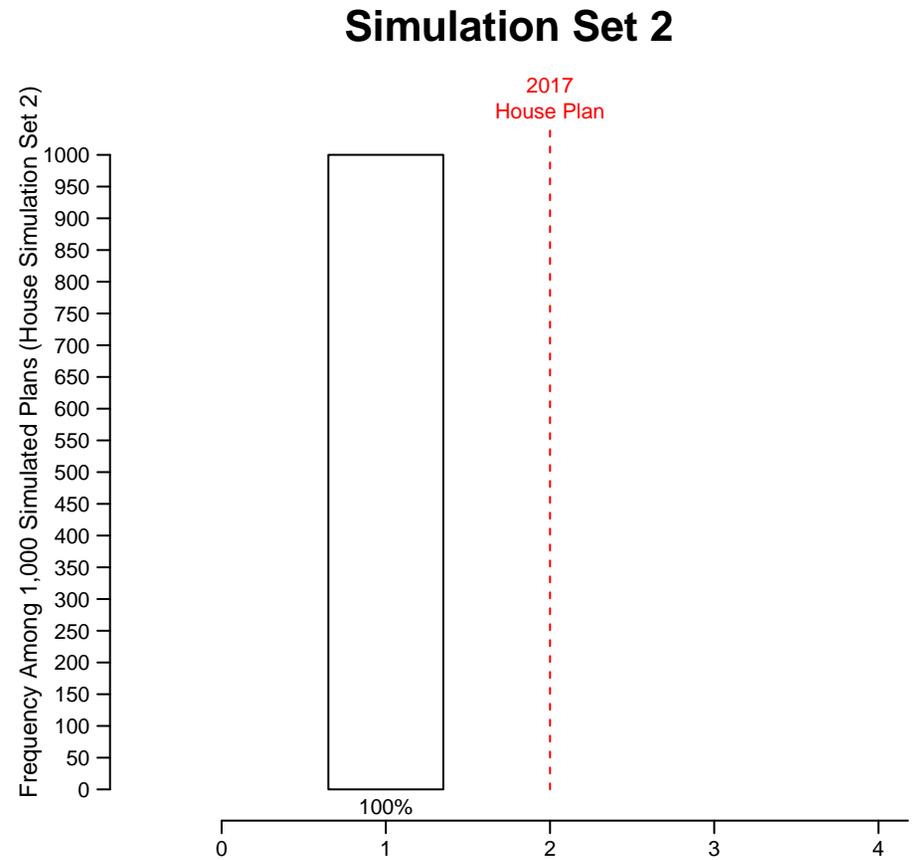
Number of Districts With At Least HD-83's Republican Vote Share of 59.31% in the Cabarrus–Davie–Montgomery–Richmond–Rowan–Stanly County Grouping (Measured Using Votes Summed Across 2010–2016 Statewide Elections)

Note: The Cabarrus–Davie–Montgomery–Richmond–Rowan–Stanly County Grouping includes the following 2017 House Plan districts: 66; 67; 76; 77; 82; 83

**Figure 59:
Number of House Districts With At Least HD-46's Republican Vote Share of 55.56% in the
Columbus-Pender-Robeson County Grouping**



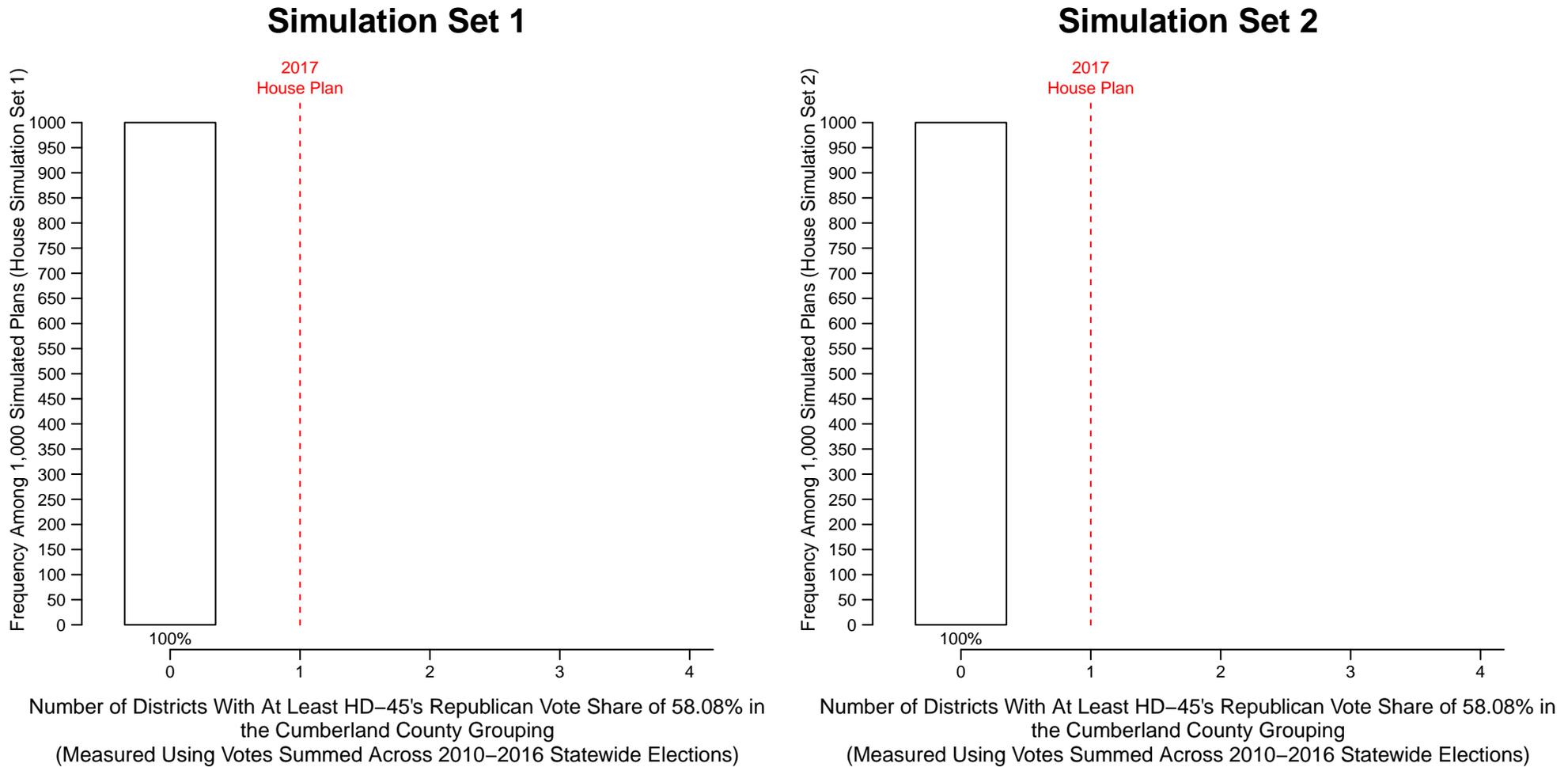
Number of Districts With At Least HD-46's Republican Vote Share of 55.56% in the Columbus-Pender-Robeson County Grouping (Measured Using Votes Summed Across 2010-2016 Statewide Elections)



Number of Districts With At Least HD-46's Republican Vote Share of 55.56% in the Columbus-Pender-Robeson County Grouping (Measured Using Votes Summed Across 2010-2016 Statewide Elections)

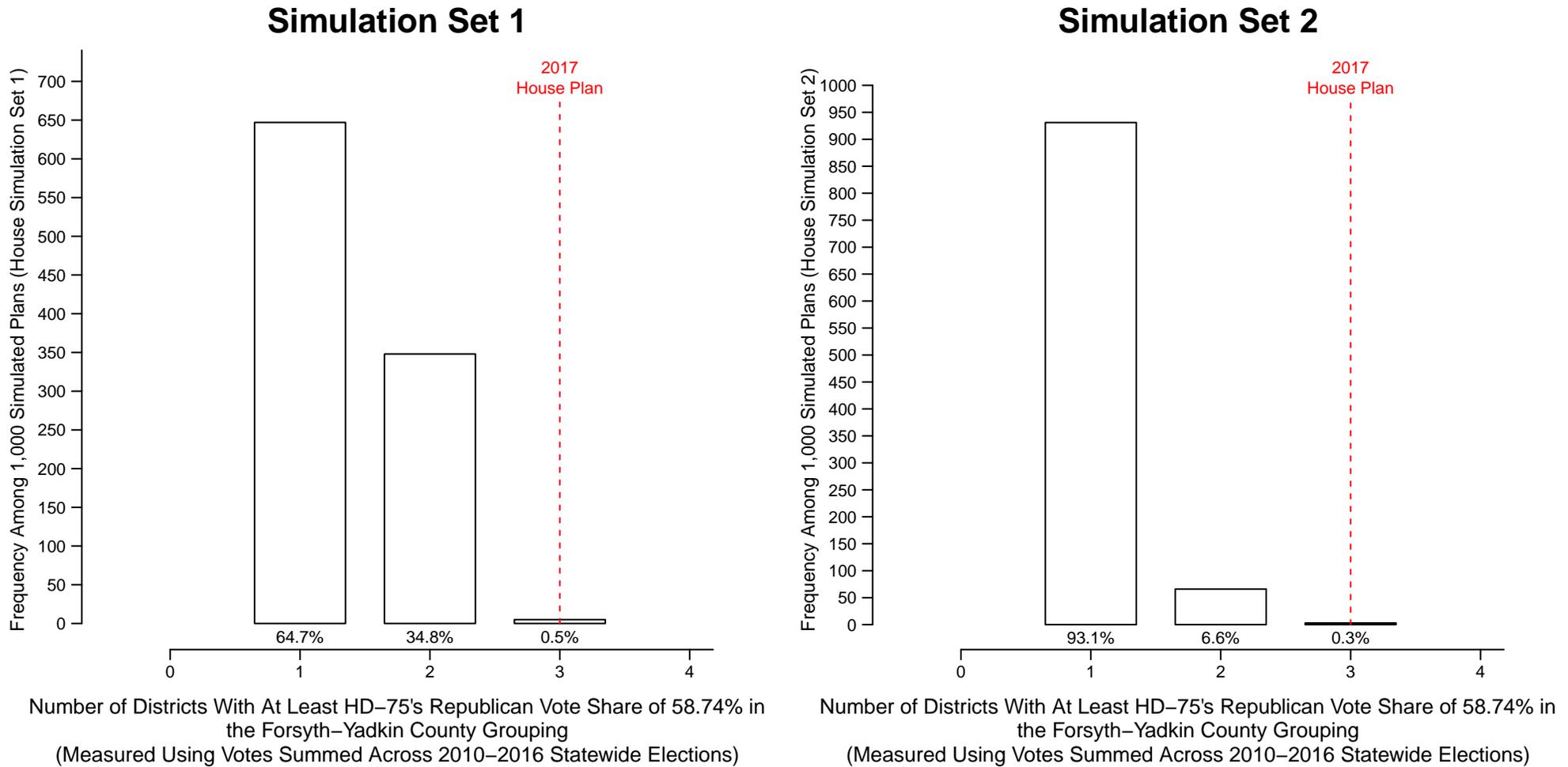
Note: The Columbus-Pender-Robeson County Grouping includes the following 2017 House Plan districts: 16; 46; 47

**Figure 60:
Number of House Districts With At Least HD-45's Republican Vote Share of 58.08% in the
Cumberland County Grouping**



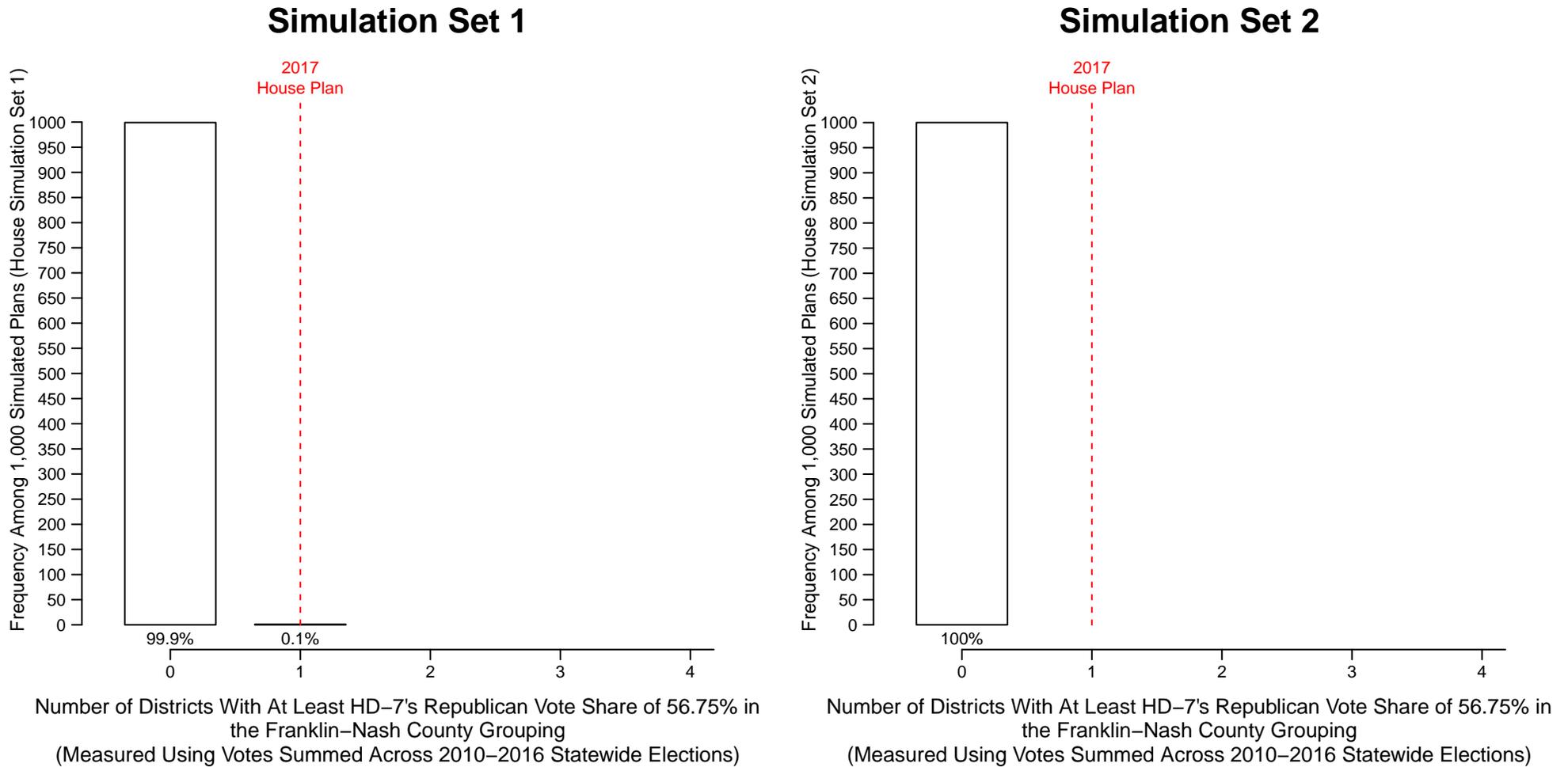
Note: The Cumberland County Grouping includes the following 2017 House Plan districts: 42; 43; 44; 45

**Figure 61:
Number of House Districts With At Least HD-75's Republican Vote Share of 58.74% in the
Forsyth–Yadkin County Grouping**



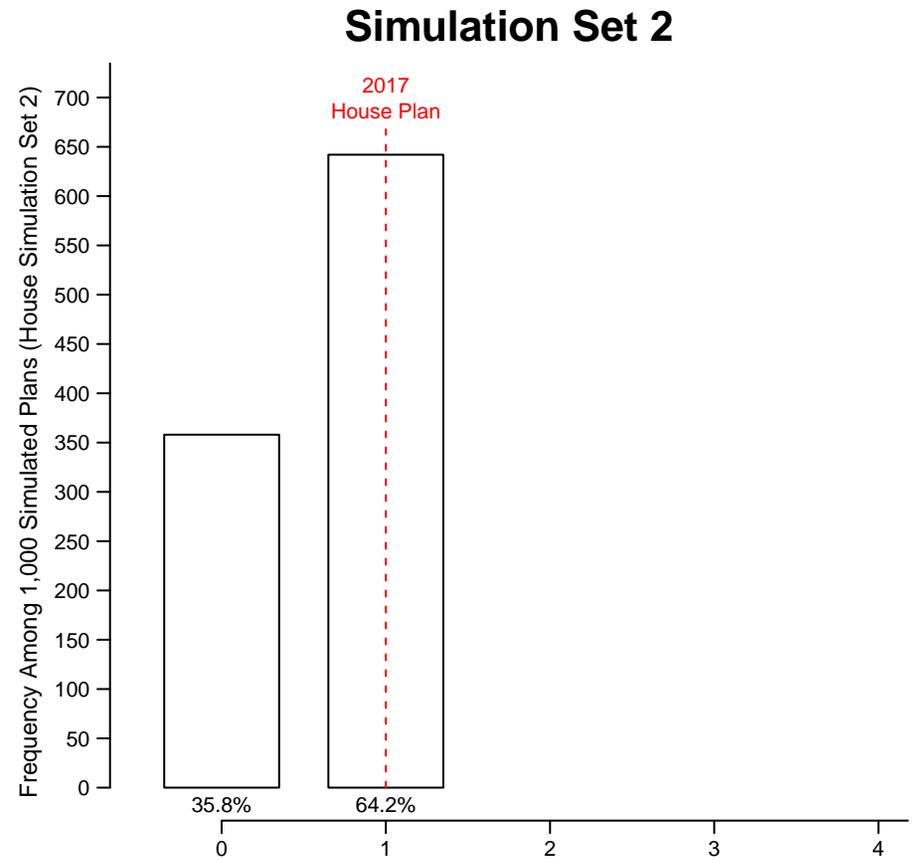
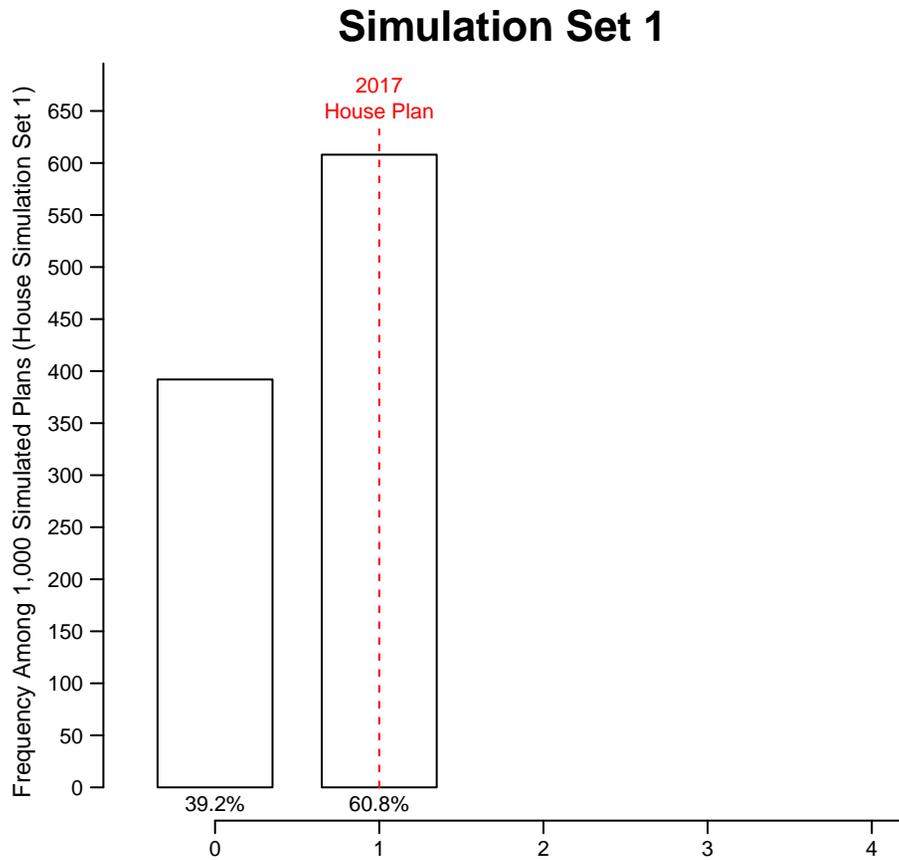
Note: The Forsyth–Yadkin County Grouping includes the following 2017 House Plan districts: 71; 72; 73; 74; 75

**Figure 62:
Number of House Districts With At Least HD-7's Republican Vote Share of 56.75% in the Franklin-Nash County Grouping**



Note: The Franklin-Nash County Grouping includes the following 2017 House Plan districts: 7; 25

**Figure 63:
Number of House Districts With At Least HD-2's Republican Vote Share of 56.12% in the
Granville–Person–Vance–Warren County Grouping**

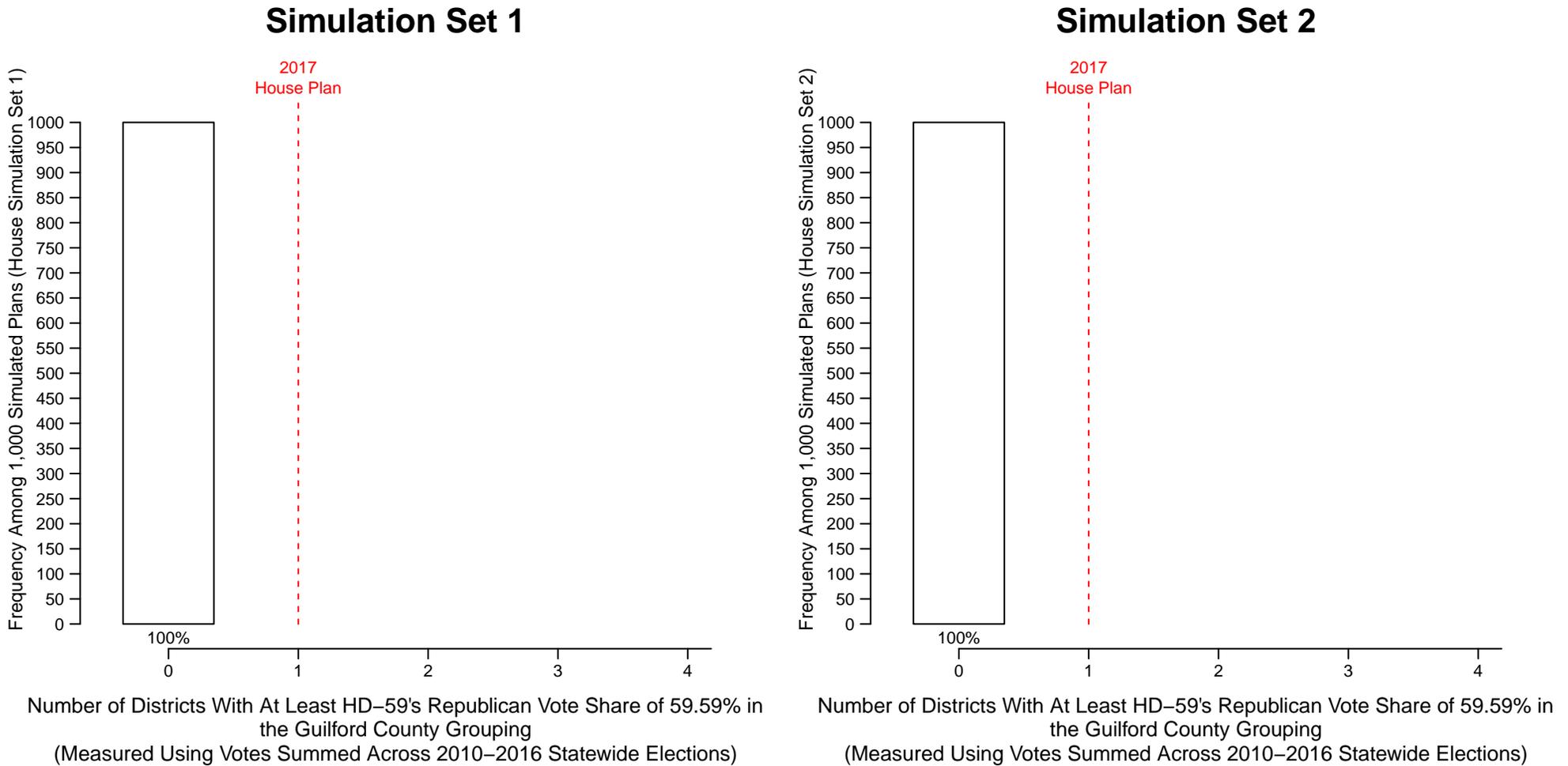


Number of Districts With At Least HD-2's Republican Vote Share of 56.12% in the Granville–Person–Vance–Warren County Grouping (Measured Using Votes Summed Across 2010–2016 Statewide Elections)

Number of Districts With At Least HD-2's Republican Vote Share of 56.12% in the Granville–Person–Vance–Warren County Grouping (Measured Using Votes Summed Across 2010–2016 Statewide Elections)

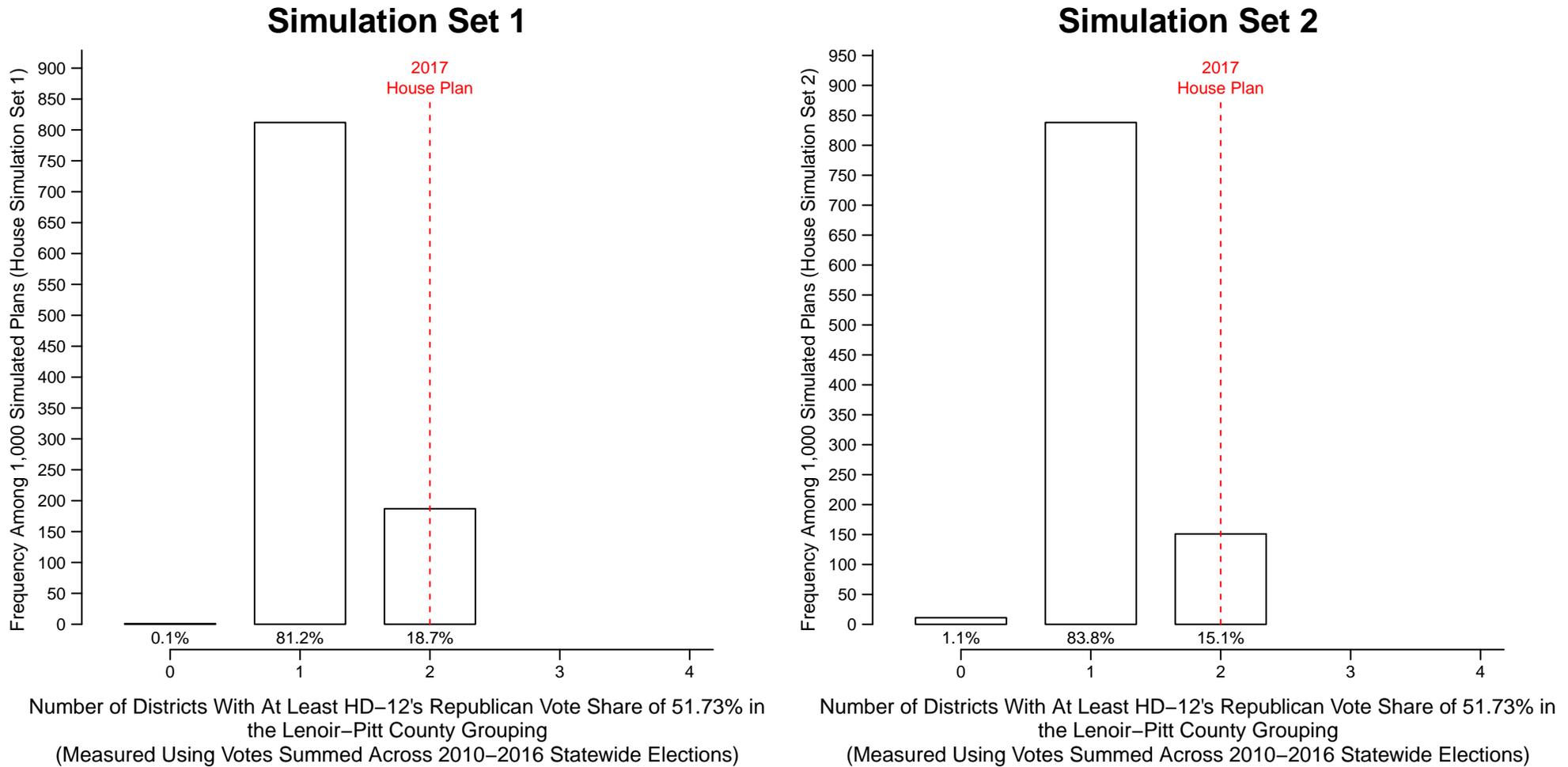
Note: The Granville–Person–Vance–Warren County Grouping includes the following 2017 House Plan districts: 2; 32

**Figure 64:
Number of House Districts With At Least HD-59's Republican Vote Share of 59.59% in the
Guilford County Grouping**



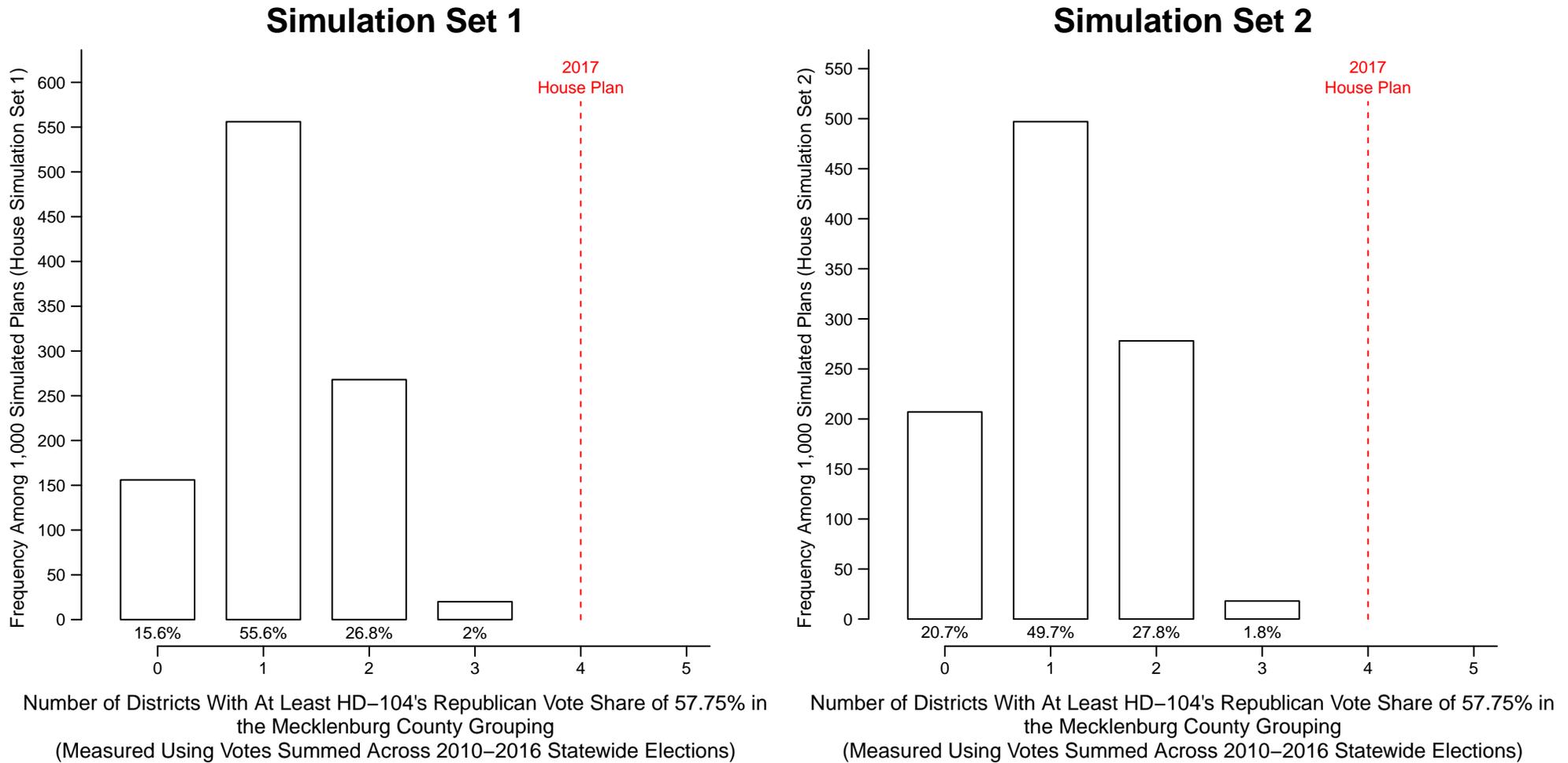
Note: The Guilford County Grouping includes the following 2017 House Plan districts: 57; 58; 59; 60; 61; 62
The Special Master-drawn districts (HD-57, HD-61, HD62) in Guilford County are excluded from the 2017 House Plan and simulation calculations in this Figure.

**Figure 65:
Number of House Districts With At Least HD-12's Republican Vote Share of 51.73% in the
Lenoir-Pitt County Grouping**



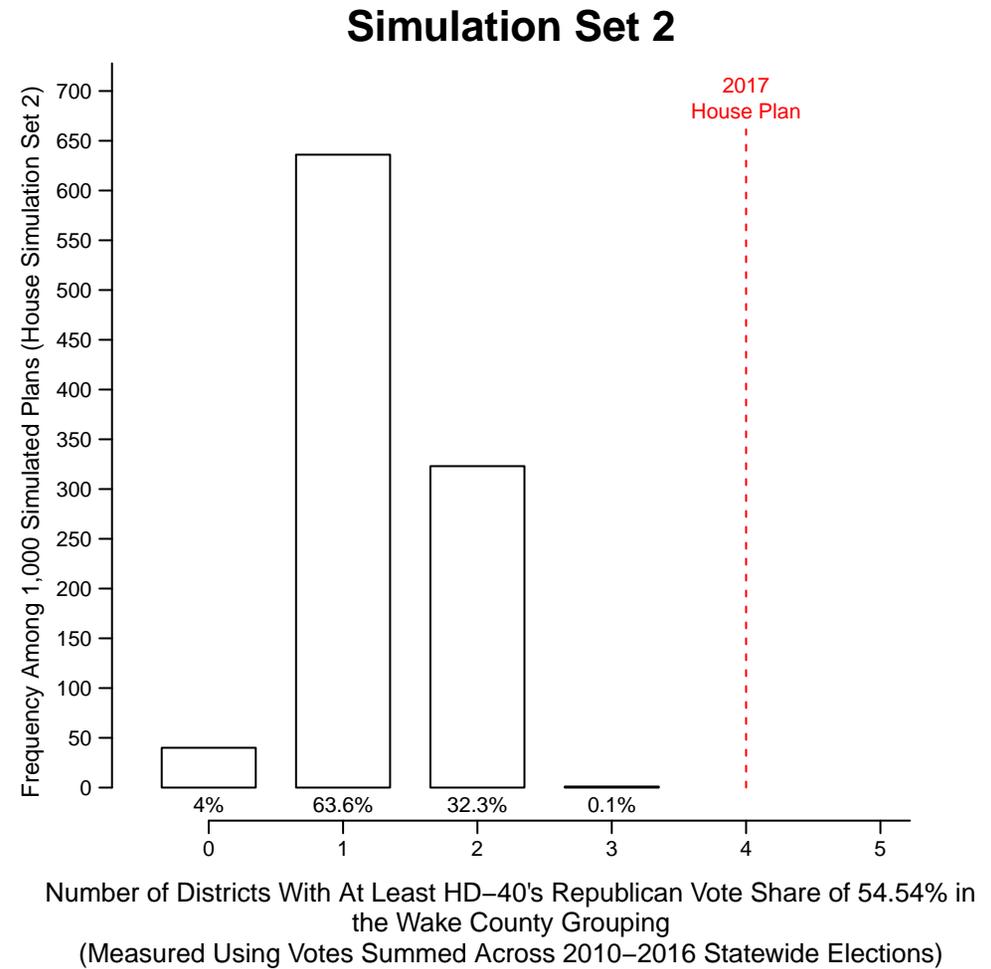
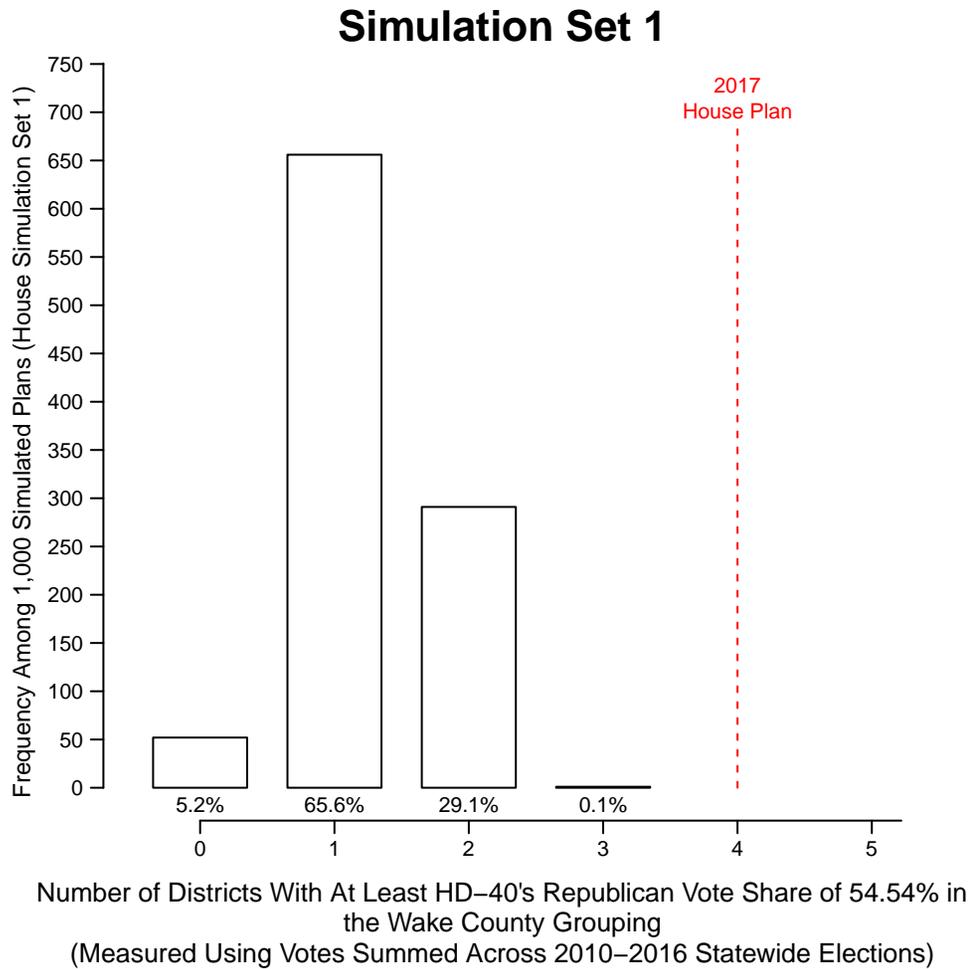
Note: The Lenoir-Pitt County Grouping includes the following 2017 House Plan districts: 8; 9; 12

**Figure 66:
Number of House Districts With At Least HD-104's Republican Vote Share of 57.75% in the Mecklenburg County Grouping**



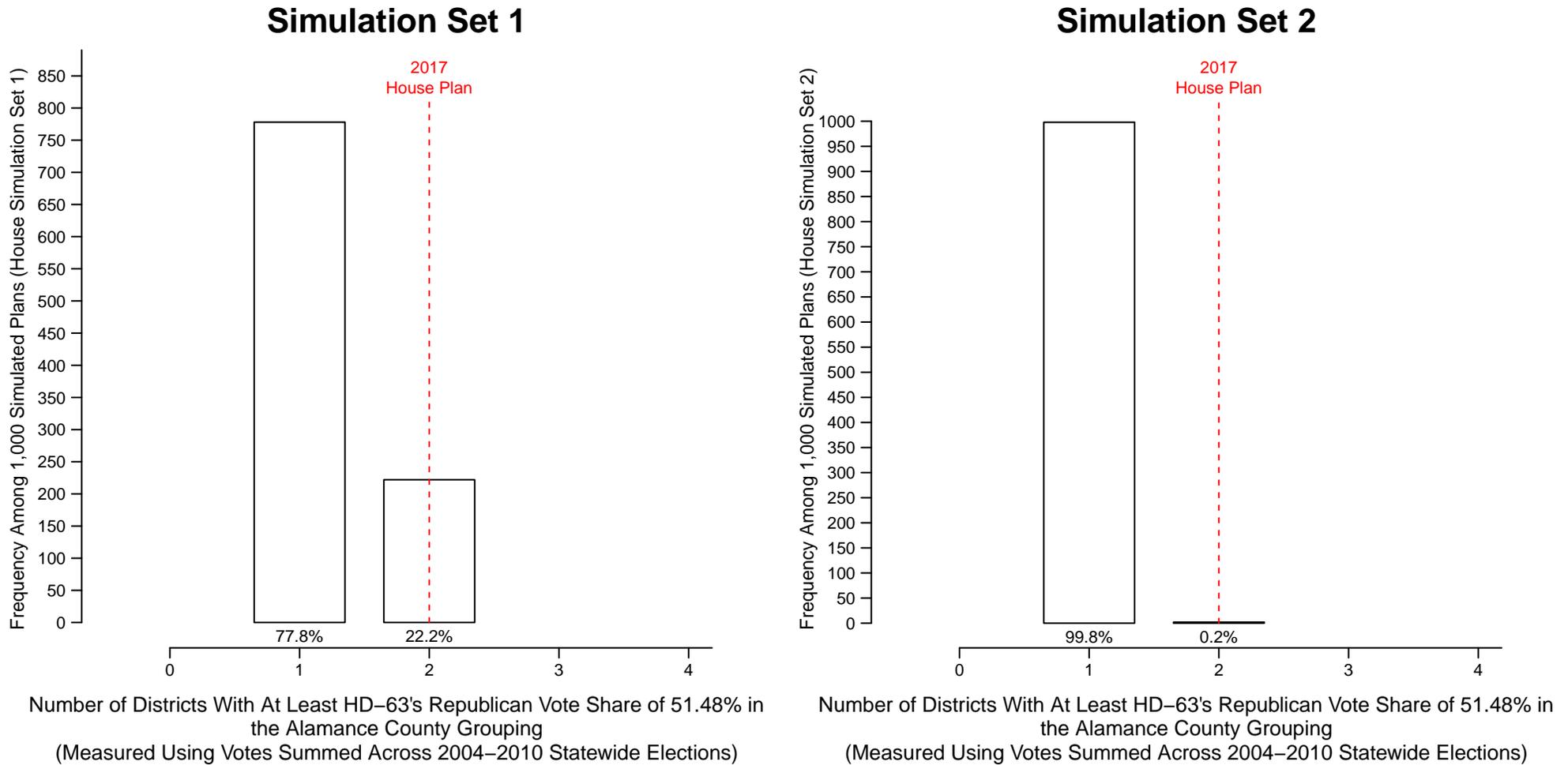
Note: The Mecklenburg County Grouping includes the following 2017 House Plan districts: 88; 92; 98; 99; 100; 101; 102; 103; 104; 105; 106; 107

**Figure 67:
Number of House Districts With At Least HD-40's Republican Vote Share of 54.54% in the
Wake County Grouping**



Note: The Wake County Grouping includes the following 2017 House Plan districts: 11; 33; 34; 35; 36; 37; 38; 39; 40; 41; 49

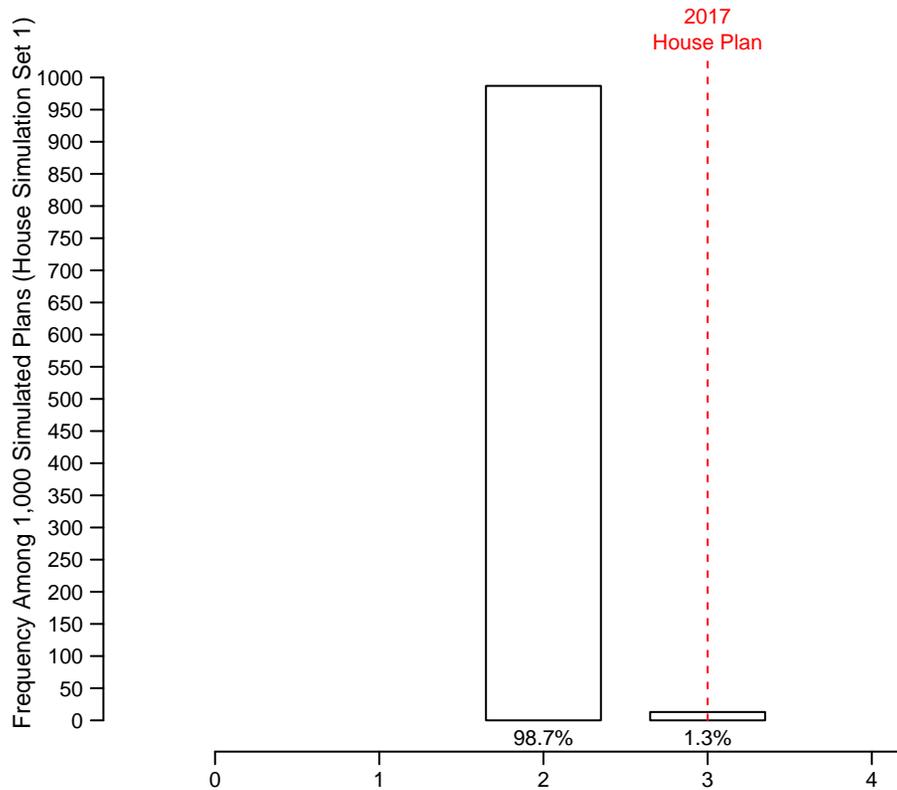
**Figure 68:
Number of House Districts With At Least HD-63's Republican Vote Share of 51.48% in the Alamance County Grouping**



Note: The Alamance County Grouping includes the following 2017 House Plan districts: 63; 64

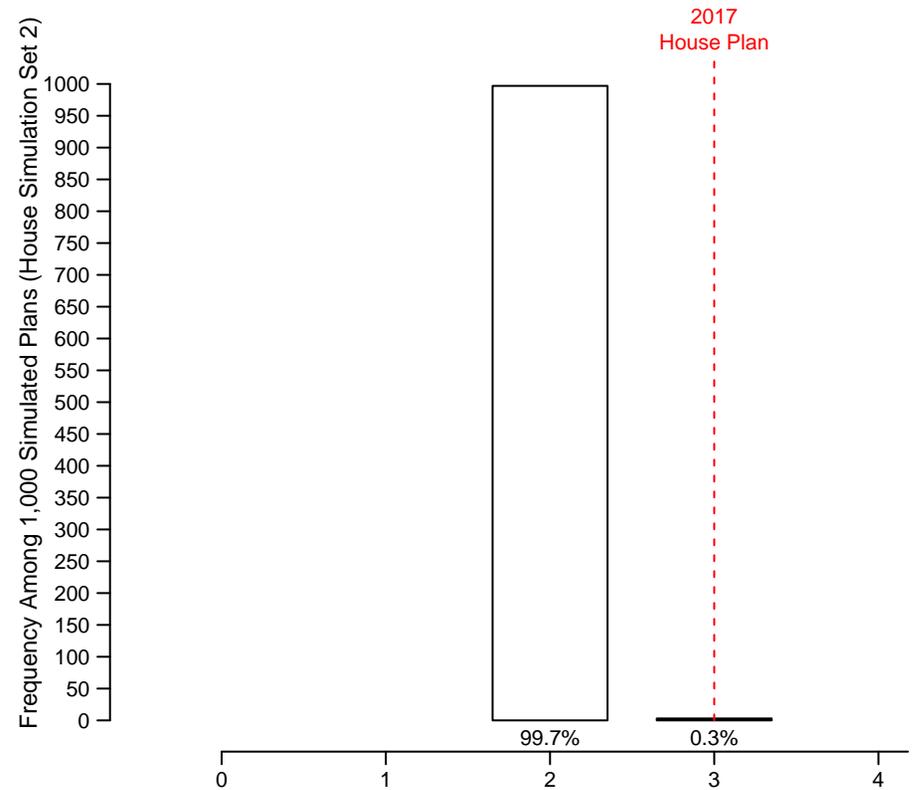
**Figure 69:
Number of House Districts With At Least HD-55's Republican Vote Share of 55.02% in the
Anson-Union County Grouping**

Simulation Set 1



Number of Districts With At Least HD-55's Republican Vote Share of 55.02% in the Anson-Union County Grouping
(Measured Using Votes Summed Across 2004-2010 Statewide Elections)

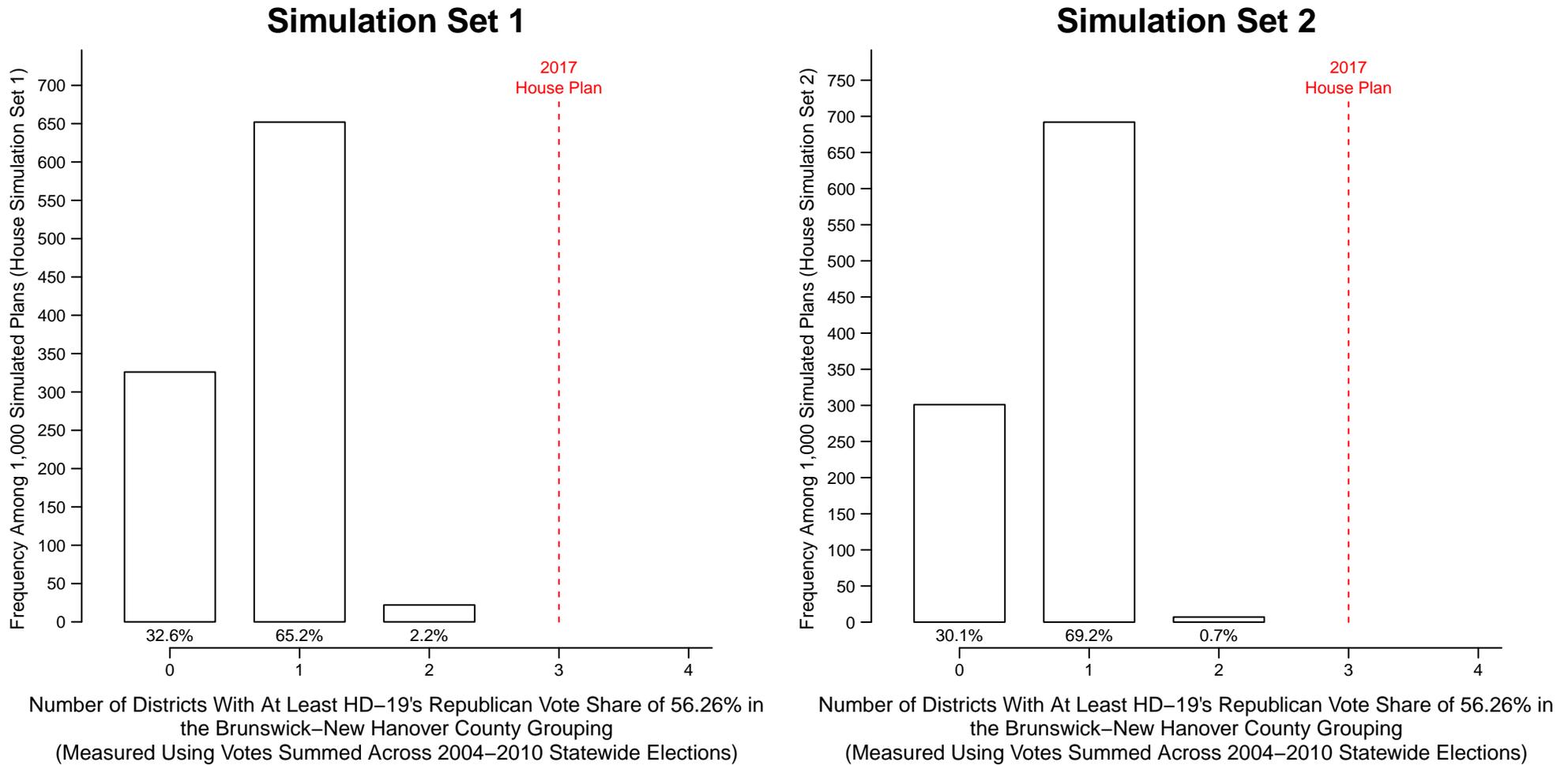
Simulation Set 2



Number of Districts With At Least HD-55's Republican Vote Share of 55.02% in the Anson-Union County Grouping
(Measured Using Votes Summed Across 2004-2010 Statewide Elections)

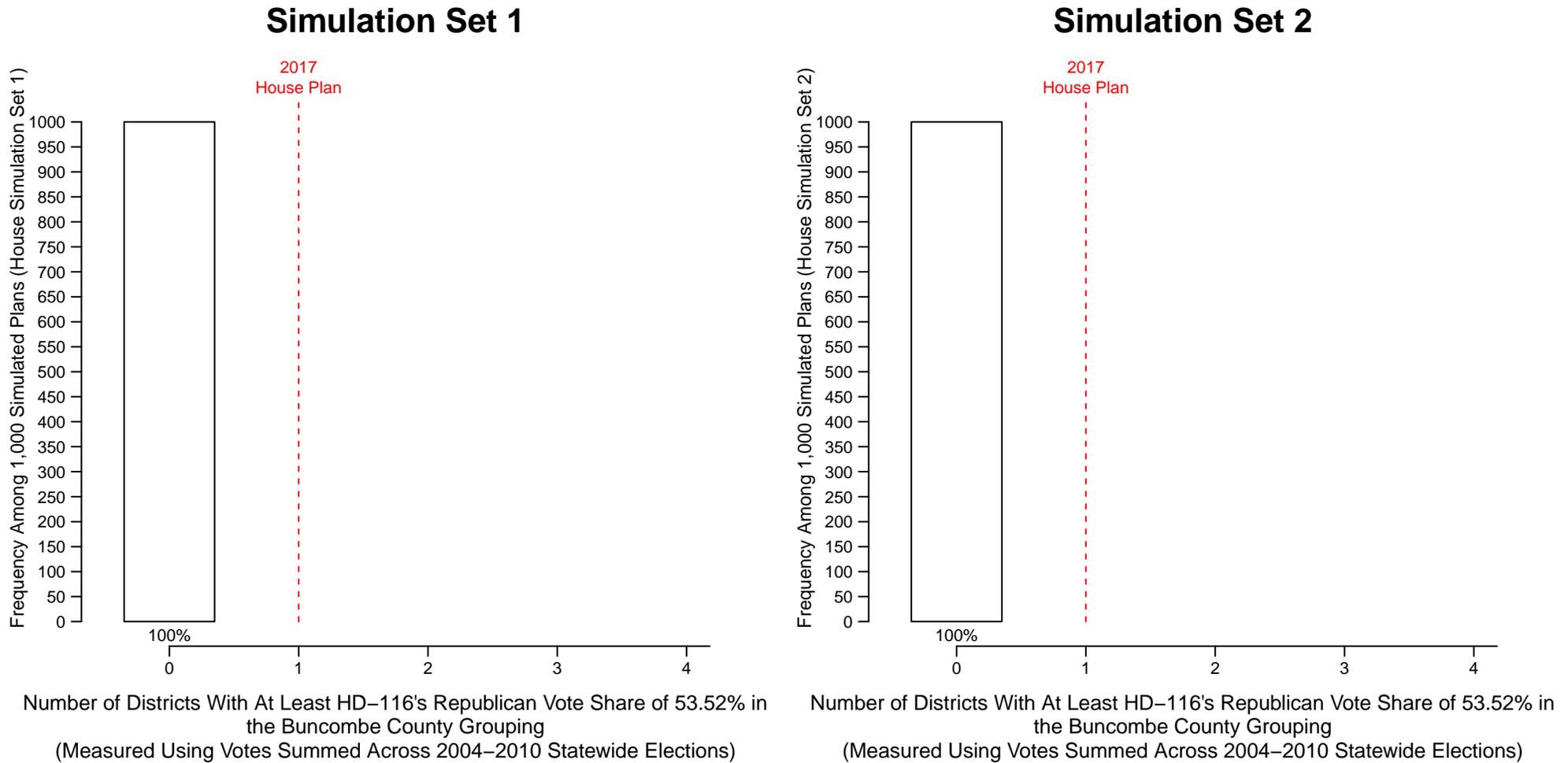
Note: The Anson-Union County Grouping includes the following 2017 House Plan districts: 55; 68; 69

**Figure 70:
Number of House Districts With At Least HD-19's Republican Vote Share of 56.26% in the
Brunswick–New Hanover County Grouping**



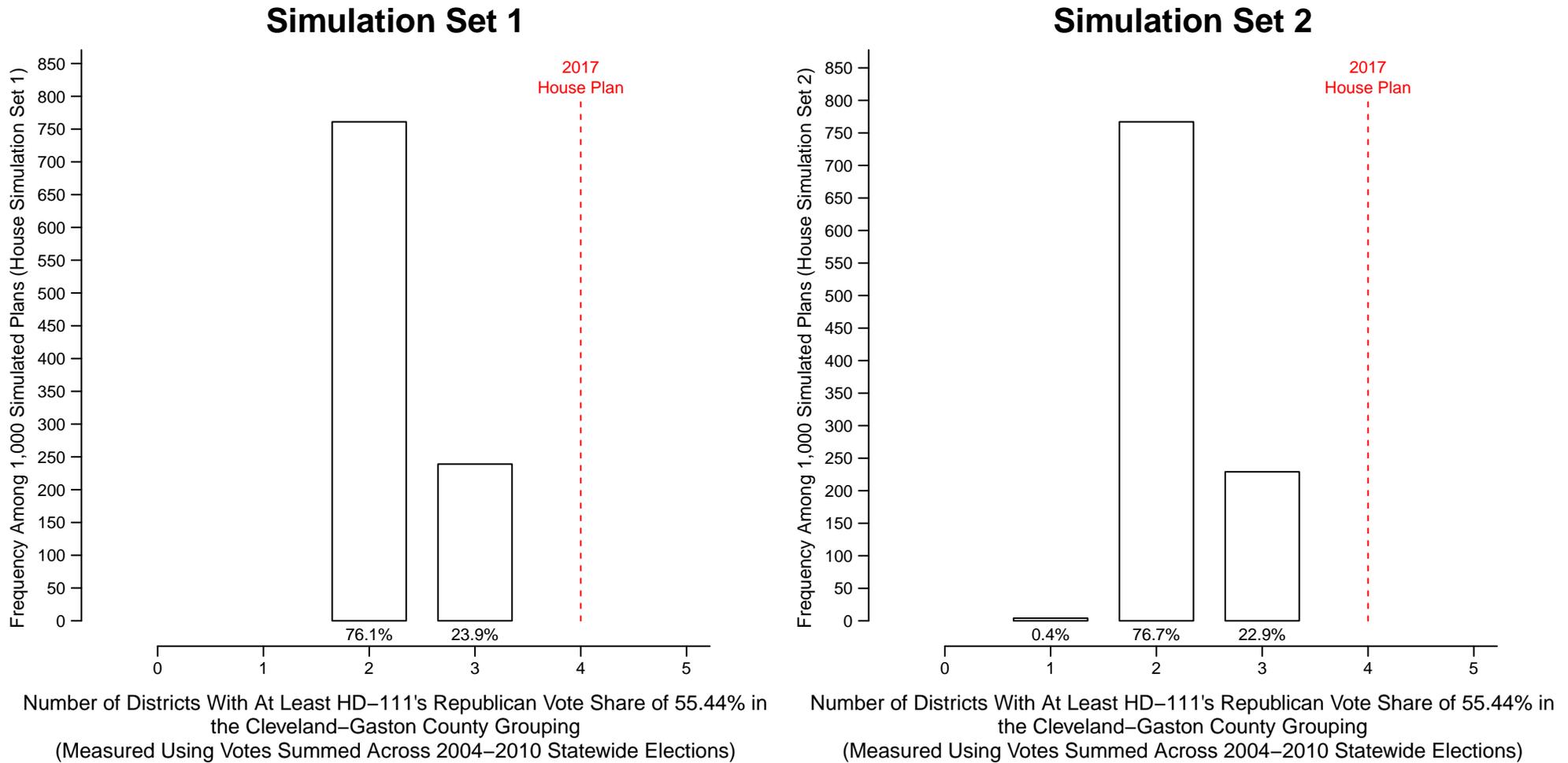
Note: The Brunswick–New Hanover County Grouping includes the following 2017 House Plan districts: 17; 18; 19; 20

**Figure 71:
Number of House Districts With At Least HD-116's Republican Vote Share of 53.52% in the Buncombe County Grouping**



Note: The Buncombe County Grouping includes the following 2017 House Plan districts: 114; 115; 116

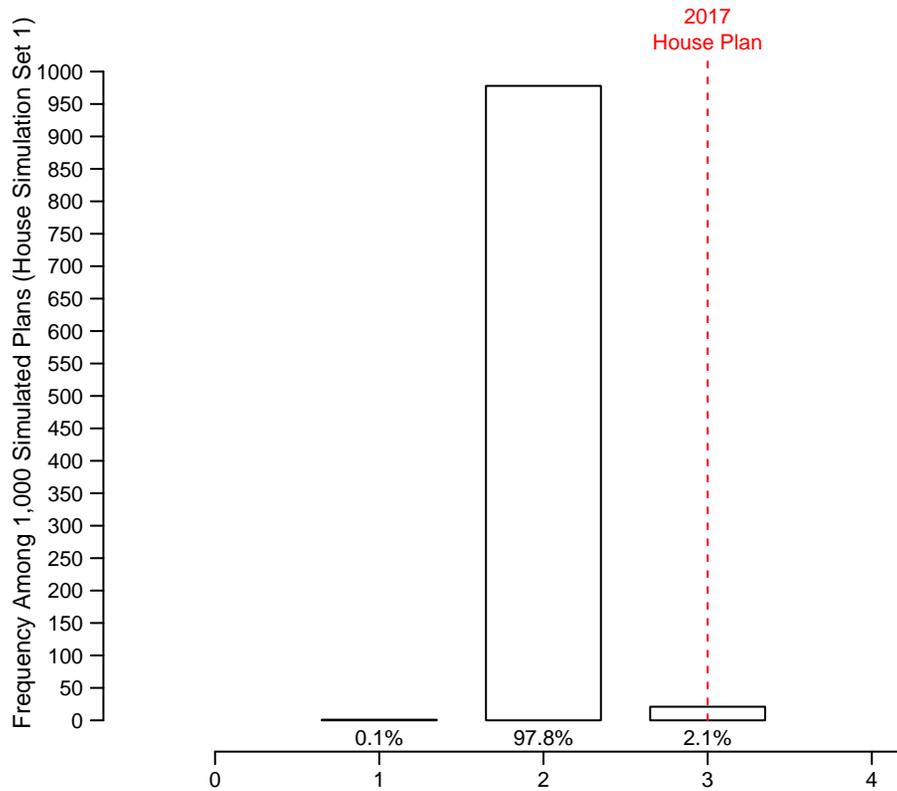
**Figure 72:
Number of House Districts With At Least HD-111's Republican Vote Share of 55.44% in the Cleveland-Gaston County Grouping**



Note: The Cleveland-Gaston County Grouping includes the following 2017 House Plan districts: 108; 109; 110; 111

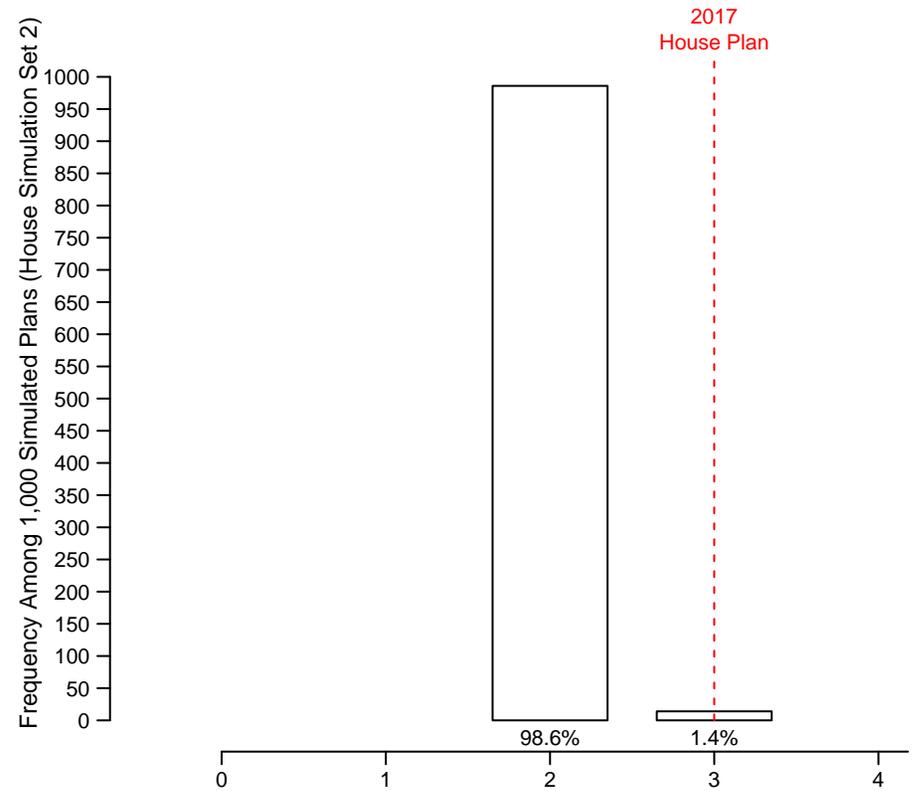
**Figure 73:
Number of House Districts With At Least HD-4's Republican Vote Share of 50.09% in the Duplin-Onslow County Grouping**

Simulation Set 1



Number of Districts With At Least HD-4's Republican Vote Share of 50.09% in the Duplin-Onslow County Grouping (Measured Using Votes Summed Across 2004-2010 Statewide Elections)

Simulation Set 2



Number of Districts With At Least HD-4's Republican Vote Share of 50.09% in the Duplin-Onslow County Grouping (Measured Using Votes Summed Across 2004-2010 Statewide Elections)

Note: The Duplin-Onslow County Grouping includes the following 2017 House Plan districts: 4; 14; 15

Grouping-by-Grouping Analysis Within County Groupings of the 2017 Senate Plan:

Using the same methodology as used for the House, I conducted a similar grouping-by-grouping analysis of the 2017 Senate Plan's districts using all of the computer-simulated Senate plans produced for this report. First, using the two sets of 1,000 simulated Senate plans described earlier in this report (Senate Simulation Set 1 and Set 2), I compared the 2017 Senate Plan's districts within each county grouping to the entire distribution of computer-simulated districts produced within the same grouping. I also compared the 2017 Senate Plan to the computer-simulated Senate plans using the same Republican threshold approach described above in my analysis of the House plans. These comparisons allowed me to identify county groupings in the 2017 Senate Plan that are partisan outliers compared to different versions of that same grouping that emerged under the computer simulations. Within each county grouping, I analyze individual districts using the same two approaches as described earlier for the grouping-by-grouping analysis of the 2017 House Plan county groupings.

Comparing the Partisan Distribution of Districts in the Enacted and Simulated Plans:

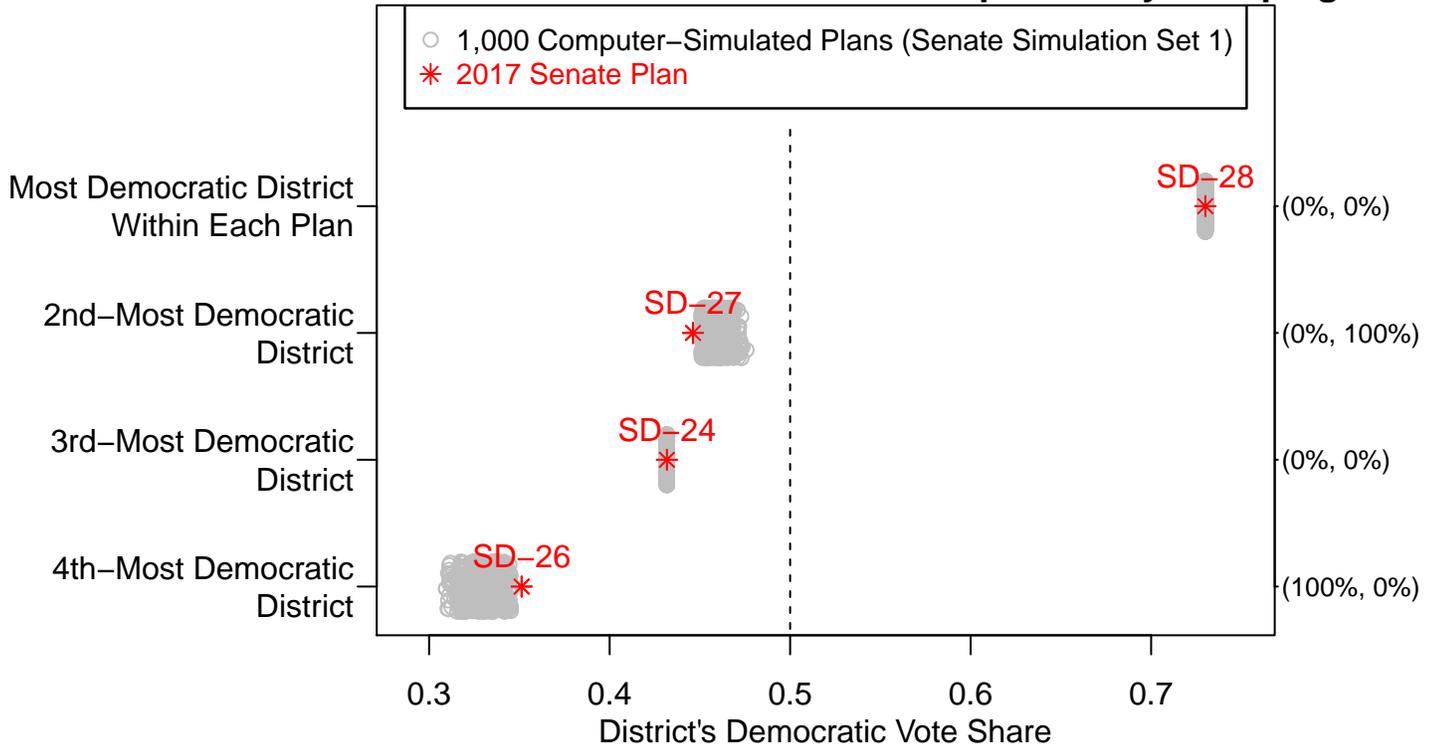
Figures 74 to 80 illustrate the grouping-by-grouping analysis for different county groupings using Senate Simulation Set 1 as a baseline for comparison and for identifying partisan outliers. Similarly, Figures 81 to 87 provide district-by-district analysis for the 2017 Senate Plan districts using Senate Simulation Set 2 as a baseline for comparison and for identifying partisan outlier districts. For county groupings containing districts that were originally drawn in 2011 and remained unchanged in the 2017 redistricting process, I used the 2004-2010 Statewide Election Composite to measure district partisanship in these Figures, since the 2004-2010 statewide elections represent the elections data available to and used by the General Assembly during the 2011 redistricting process.

Overall, using this grouping-by-grouping comparison methodology, I found that the 2017 Senate plan contains partisan outlier districts within the following seven Senate county groupings:

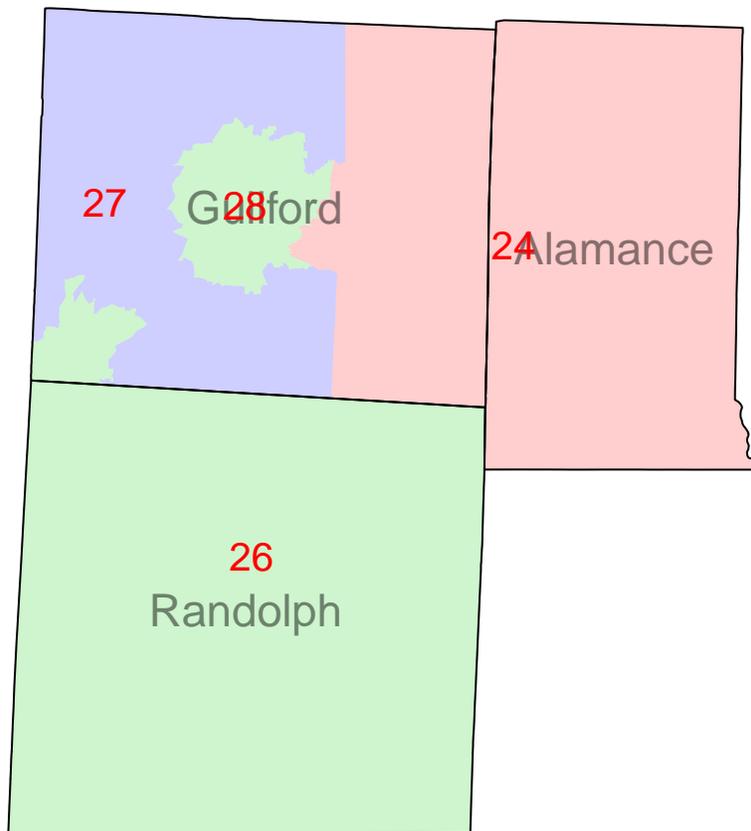
1. The Alamance-Guilford-Randolph County grouping (Figures 74 and 81).
2. The Bladen-Brunswick-New Hanover -Pender County grouping (Figures 80 and 87).
3. The Buncombe-Henderson-Transylvania County grouping (Figures 79 and 86).
4. The Davie-Forsythe County grouping (Figures 75 and 82).

5. The Duplin-Harnett-Johnston-Lee-Nash-Sampson County grouping (Figures 76 and 83).
6. The Franklin-Wake County grouping (Figures 77 and 84).
7. The Mecklenburg County grouping (Figures 78 and 85).

**Figure 74: Senate Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Alamance-Guilford-Randolph County Grouping**

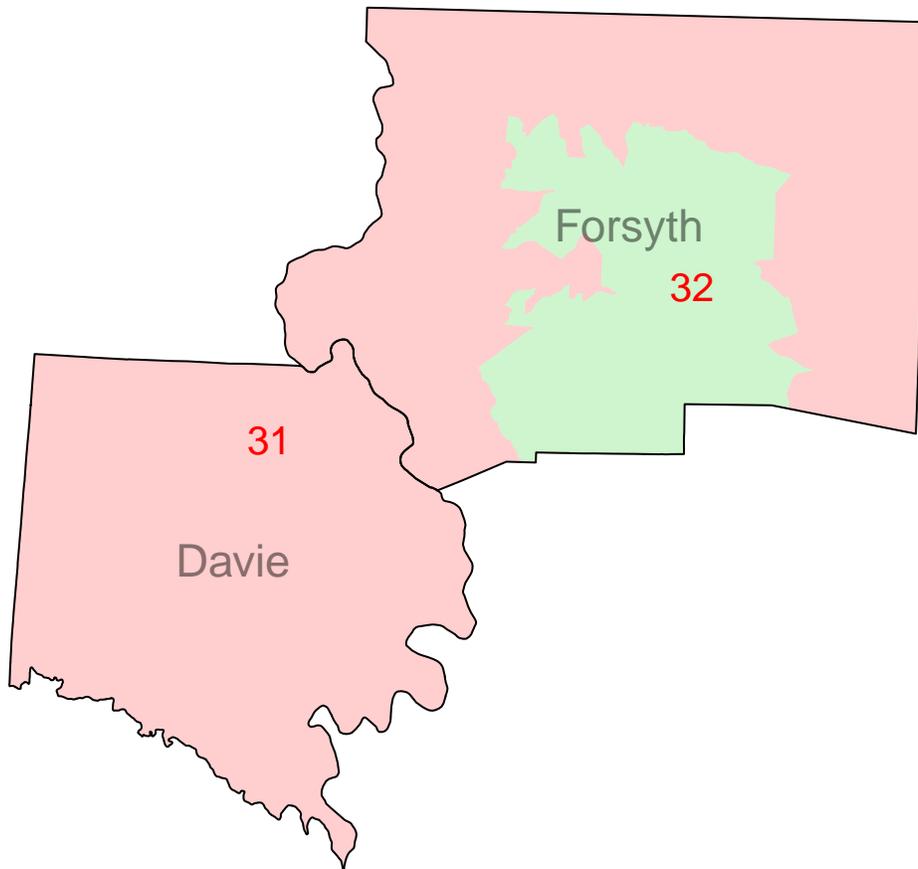
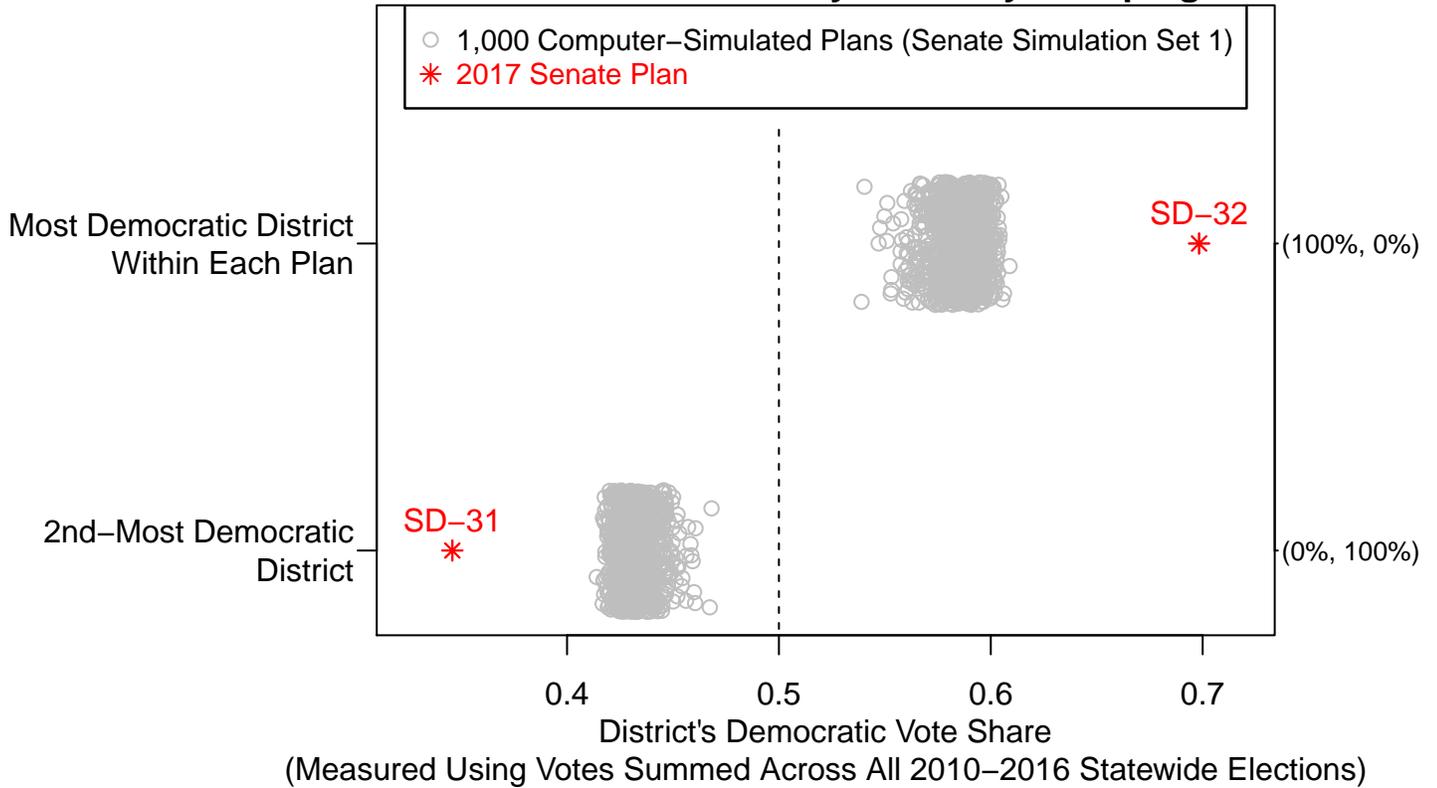


(Measured Using Votes Summed Across All 2010–2016 Statewide Elections)



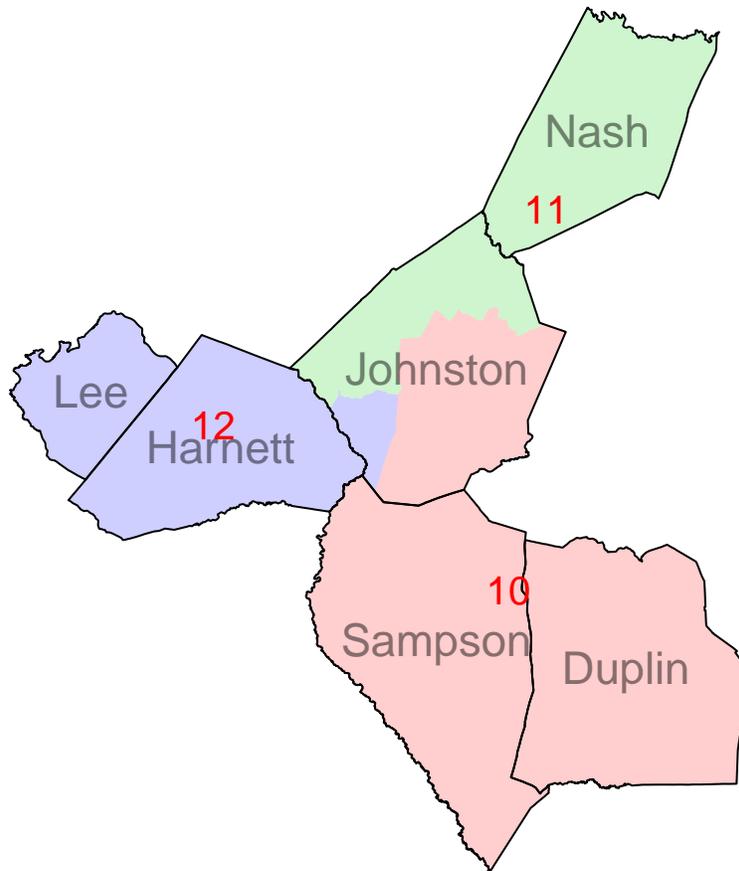
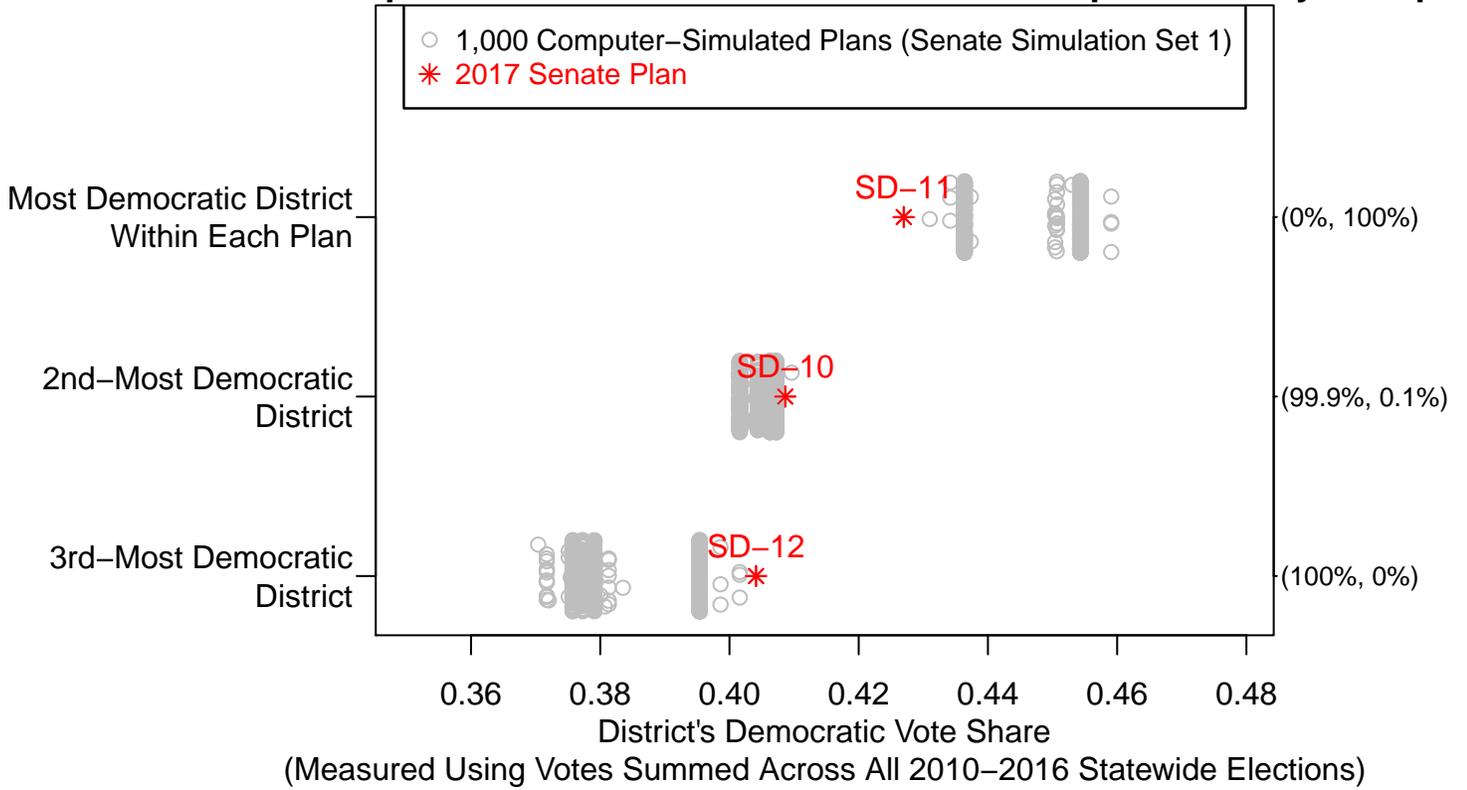
2017 Enacted Senate Plan Districts Within County Grouping 1
(Contains 4 districts, including 2 Special Master Districts (SD-24 and SD-28)
that are frozen in all simulated plans and included in the above Figure)

**Figure 75: Senate Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Davie-Forsyth County Grouping**



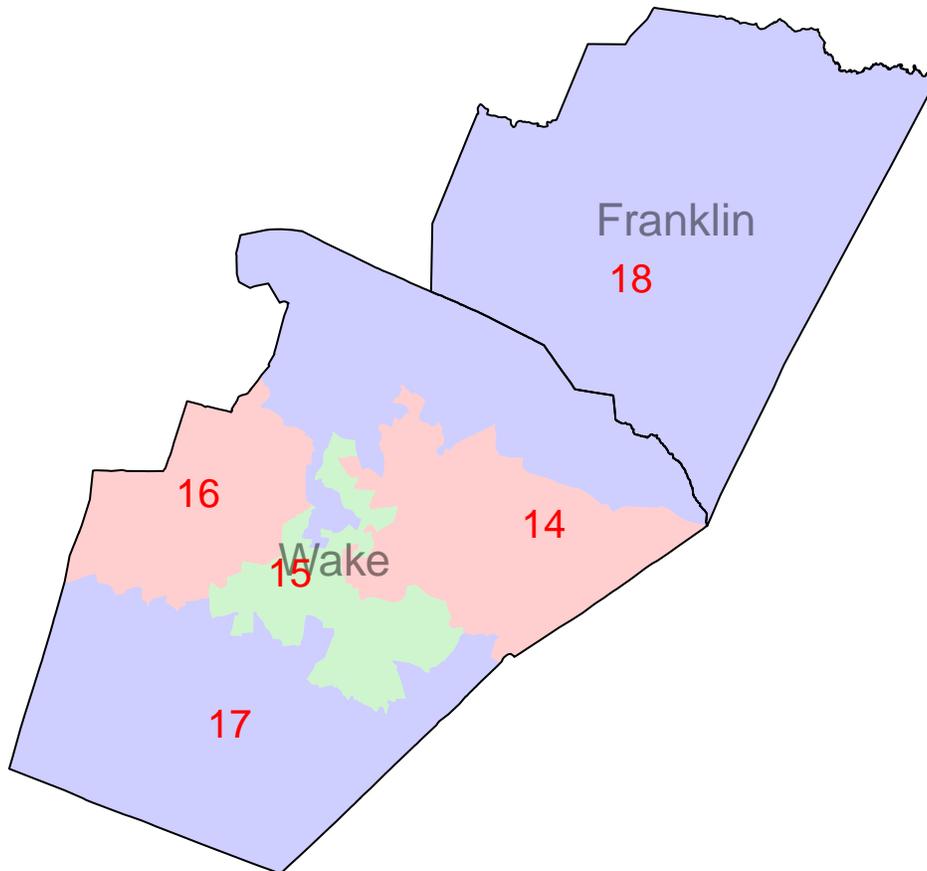
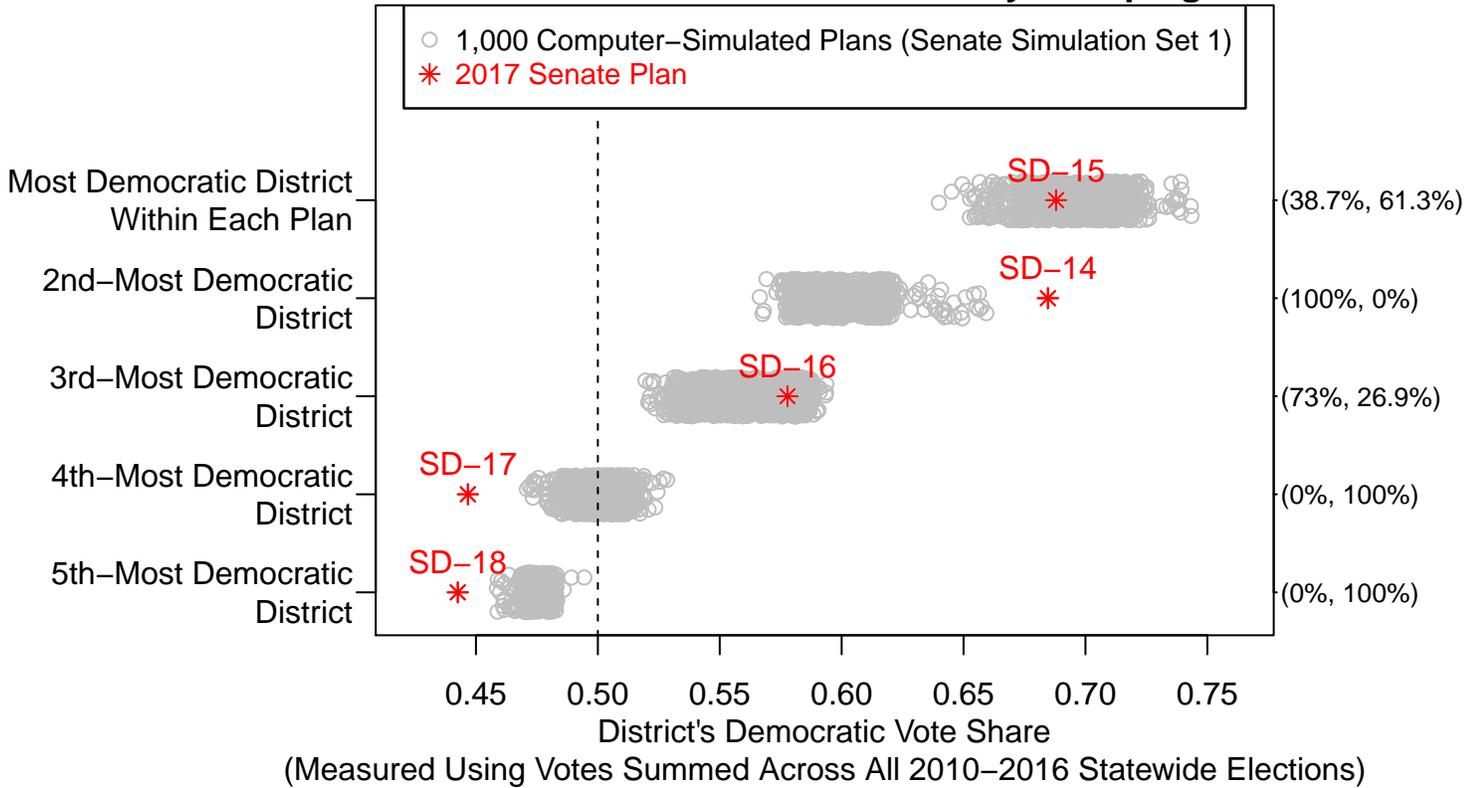
2017 Enacted Senate Plan Districts Within County Grouping 18 (Contains 2 Districts)

**Figure 76: Senate Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Duplin-Harnett-Johnston-Lee-Nash-Sampson County Grouping**



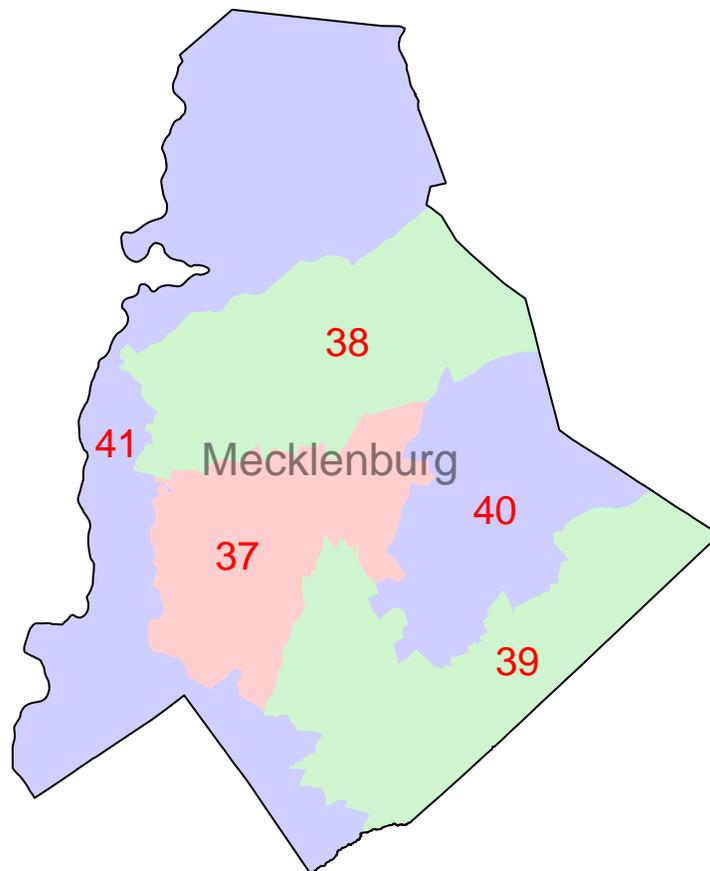
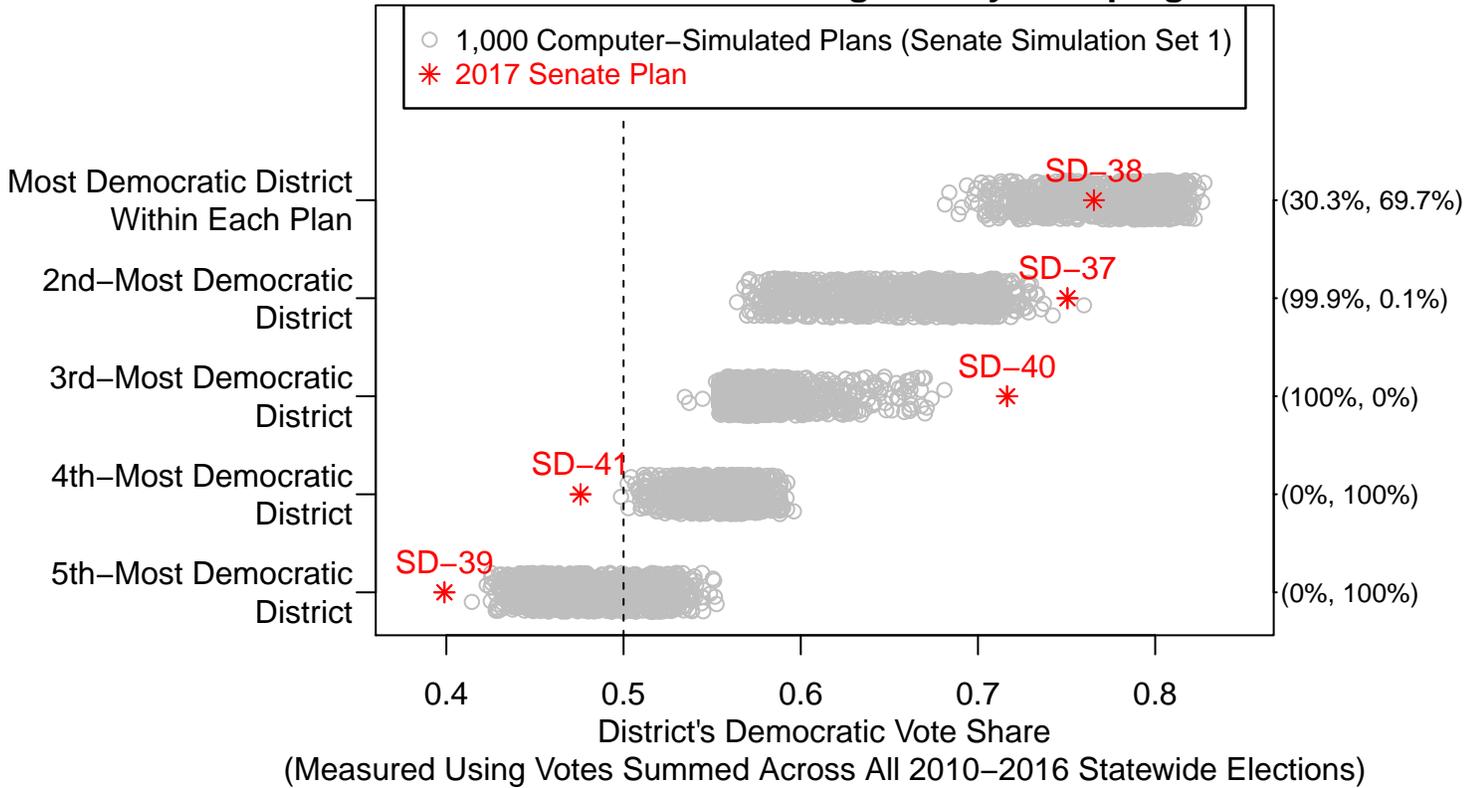
2017 Enacted Senate Plan Districts Within County Grouping 19 (Contains 3 Districts)

**Figure 77: Senate Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Franklin-Wake County Grouping**



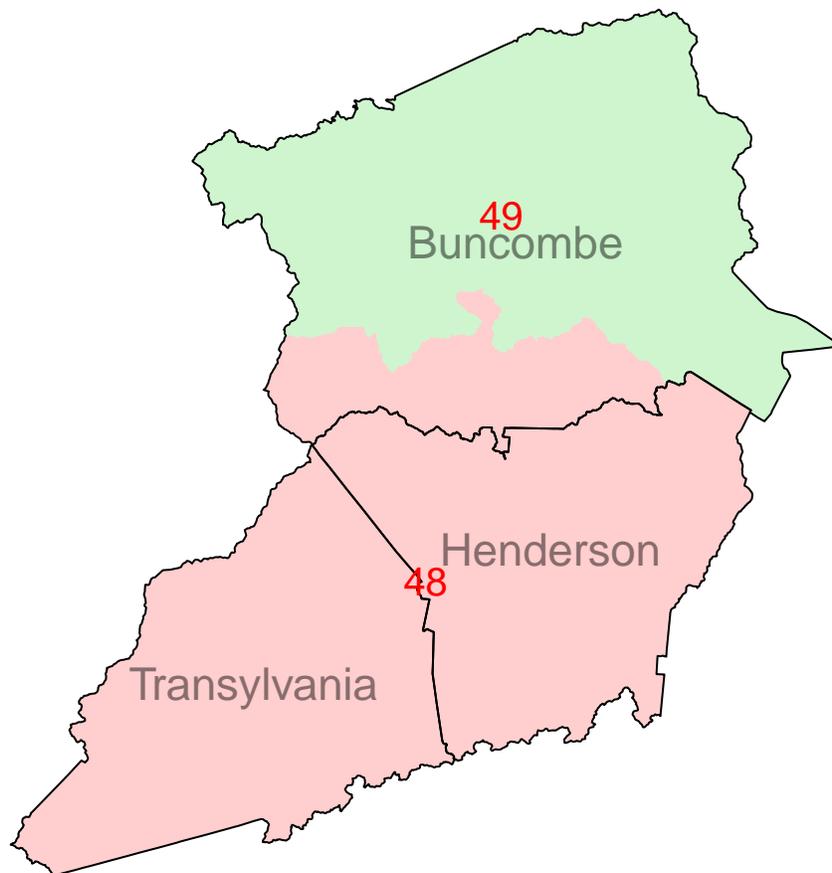
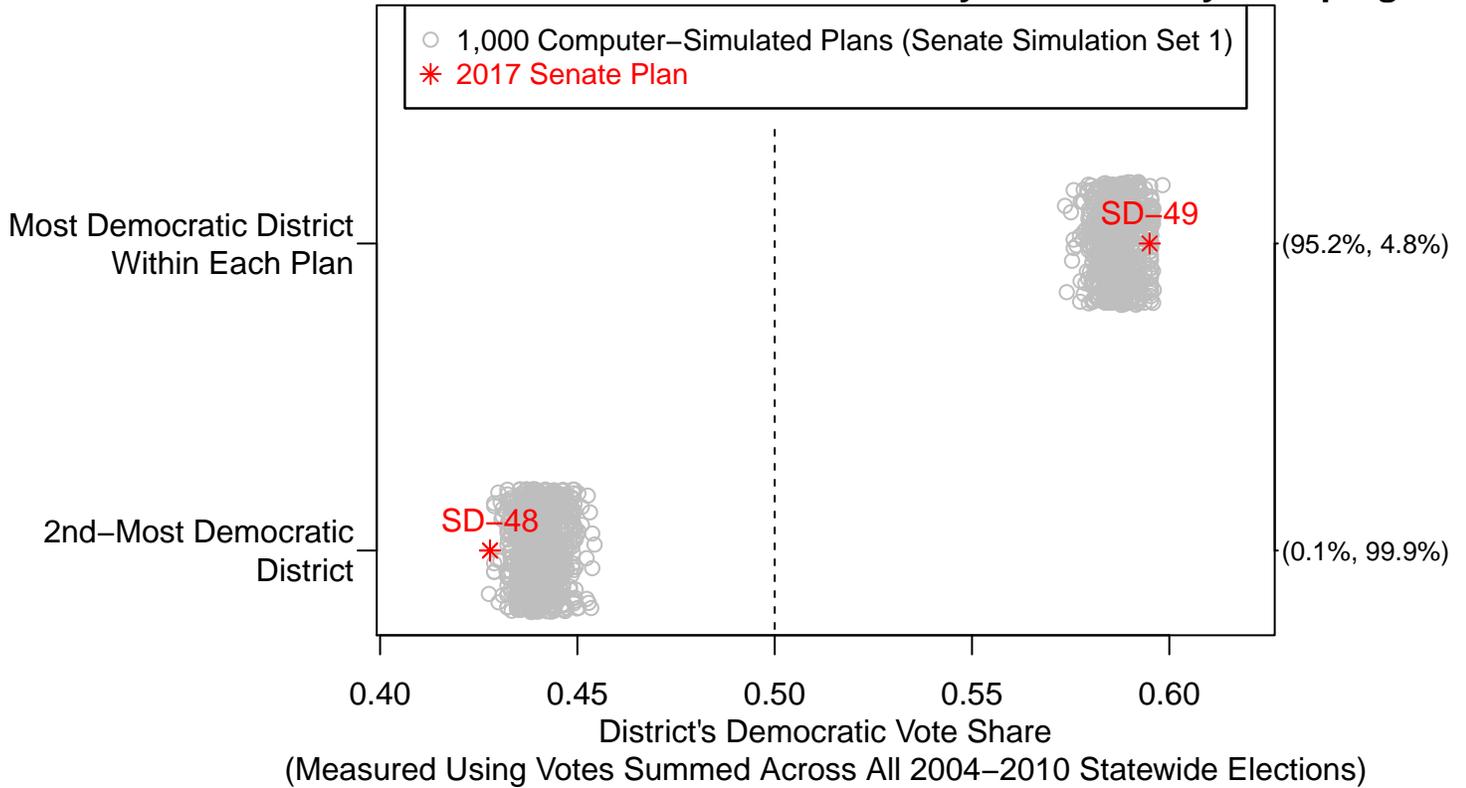
2017 Enacted Senate Plan Districts Within County Grouping 22 (Contains 5 Districts)

**Figure 78: Senate Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Mecklenburg County Grouping**



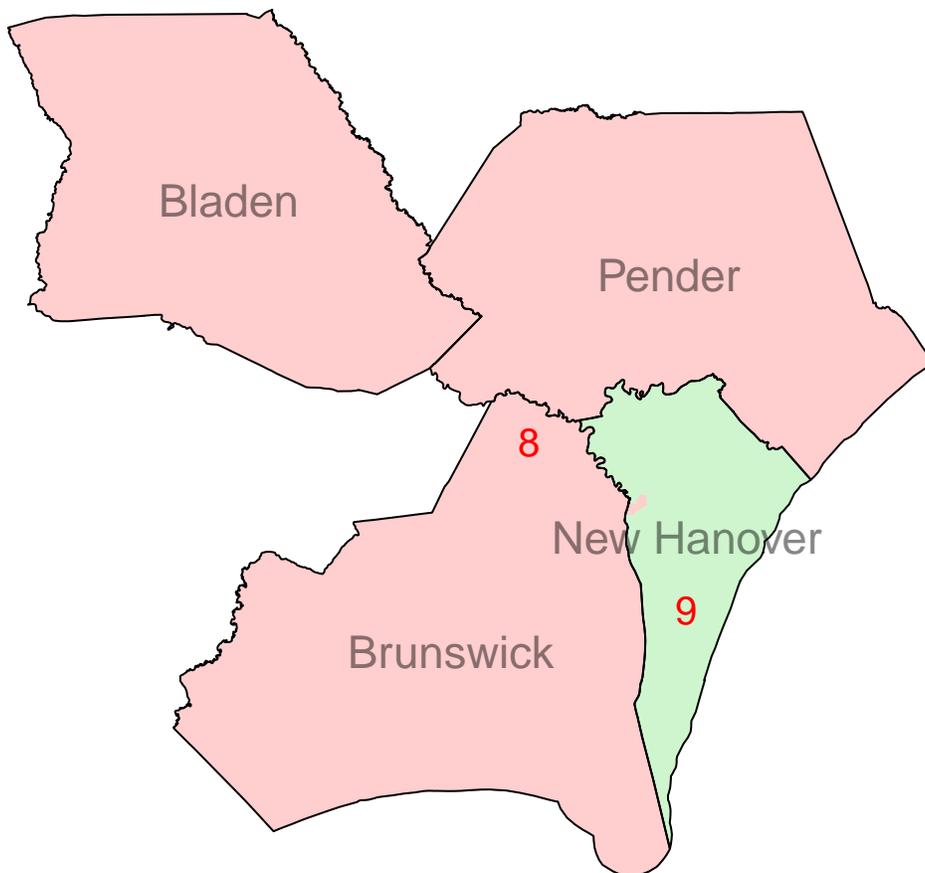
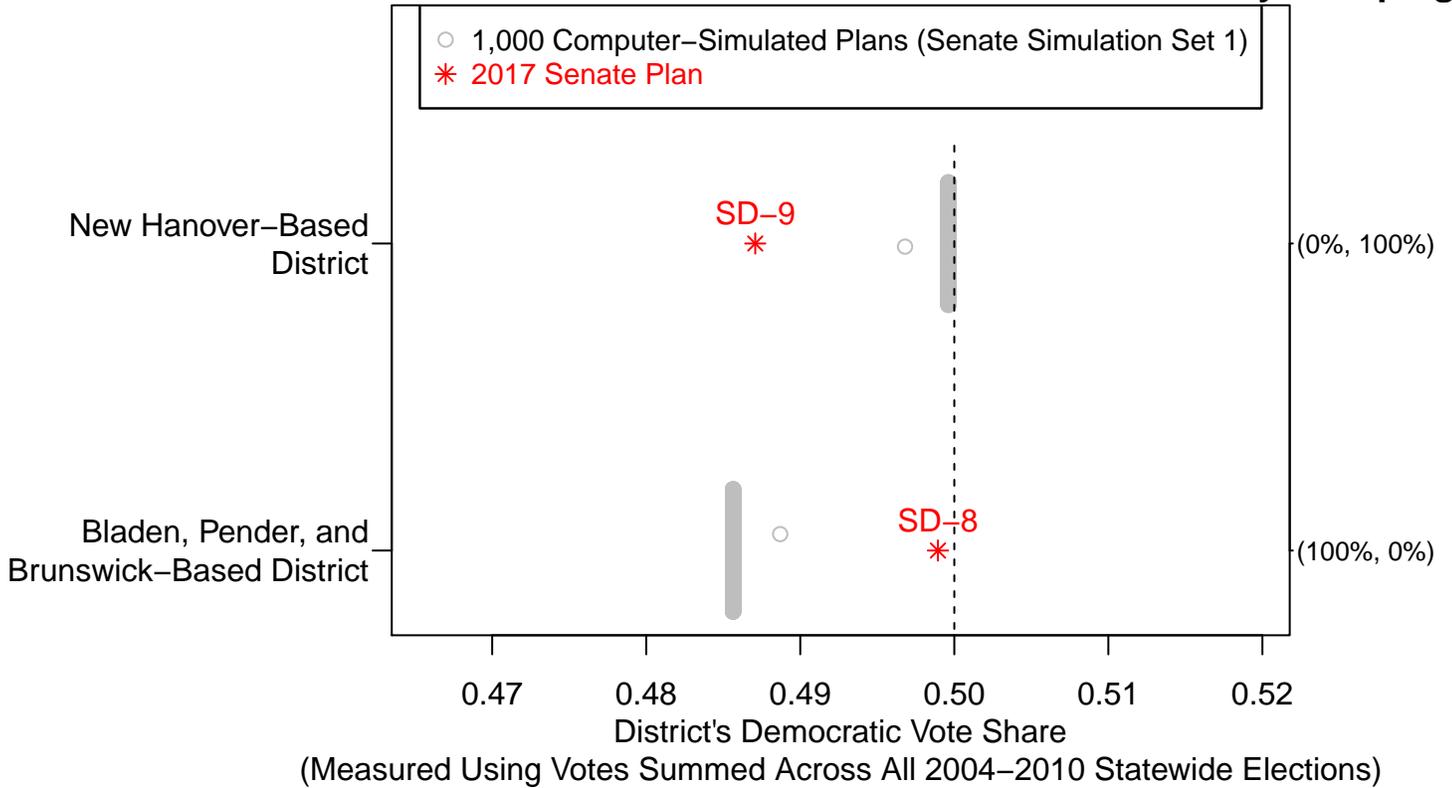
2017 Enacted Senate Plan Districts Within County Grouping 28 (Contains 5 Districts)

**Figure 79: Senate Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Buncombe–Henderson–Transylvania County Grouping**



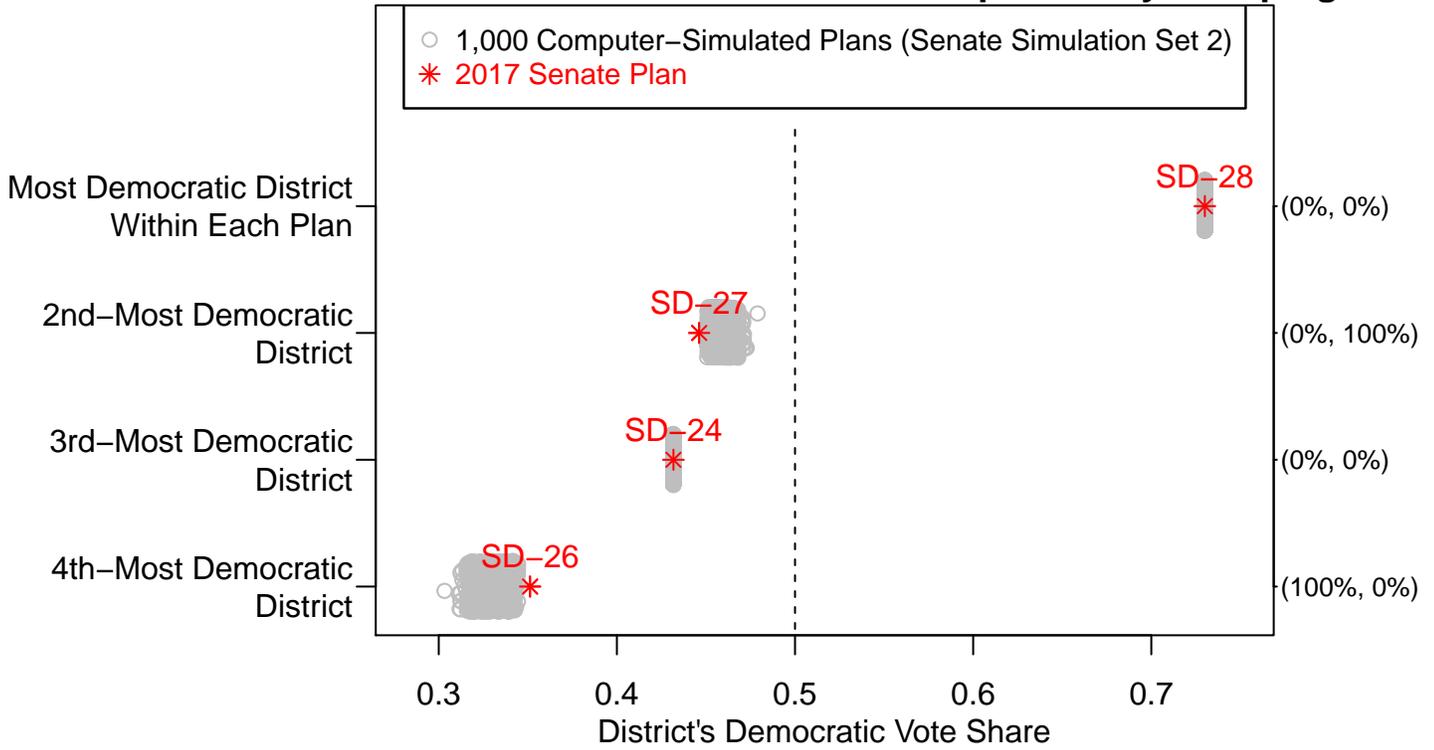
2017 Enacted Senate Plan Districts (2 Districts)

**Figure 80: Senate Simulation Set 1:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Bladen-Brunswick-New Hanover-Pender County Grouping**

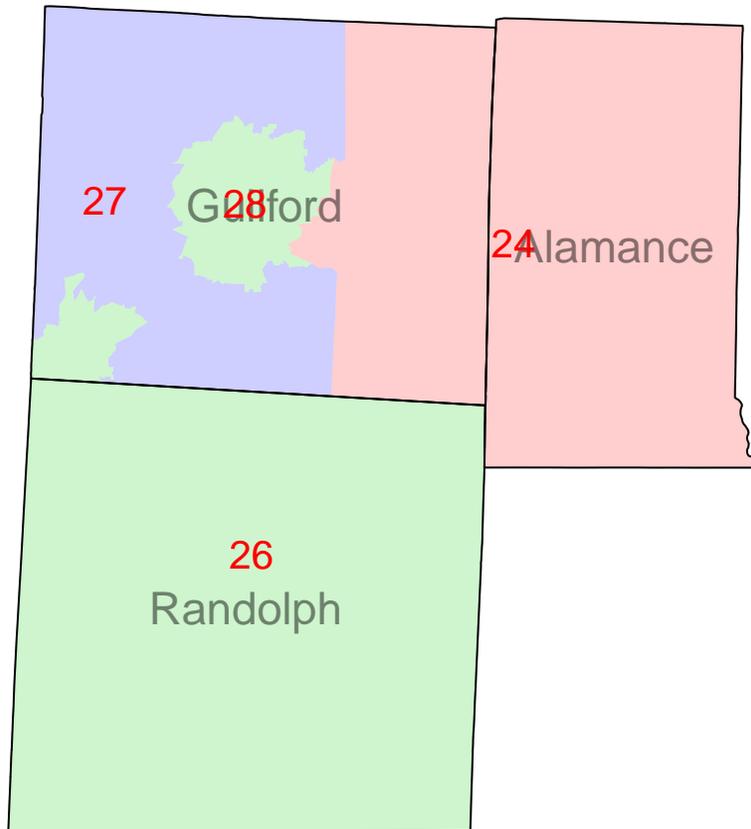


2017 Enacted Senate Plan Districts (2 Districts)

**Figure 81: Senate Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Alamance-Guilford-Randolph County Grouping**

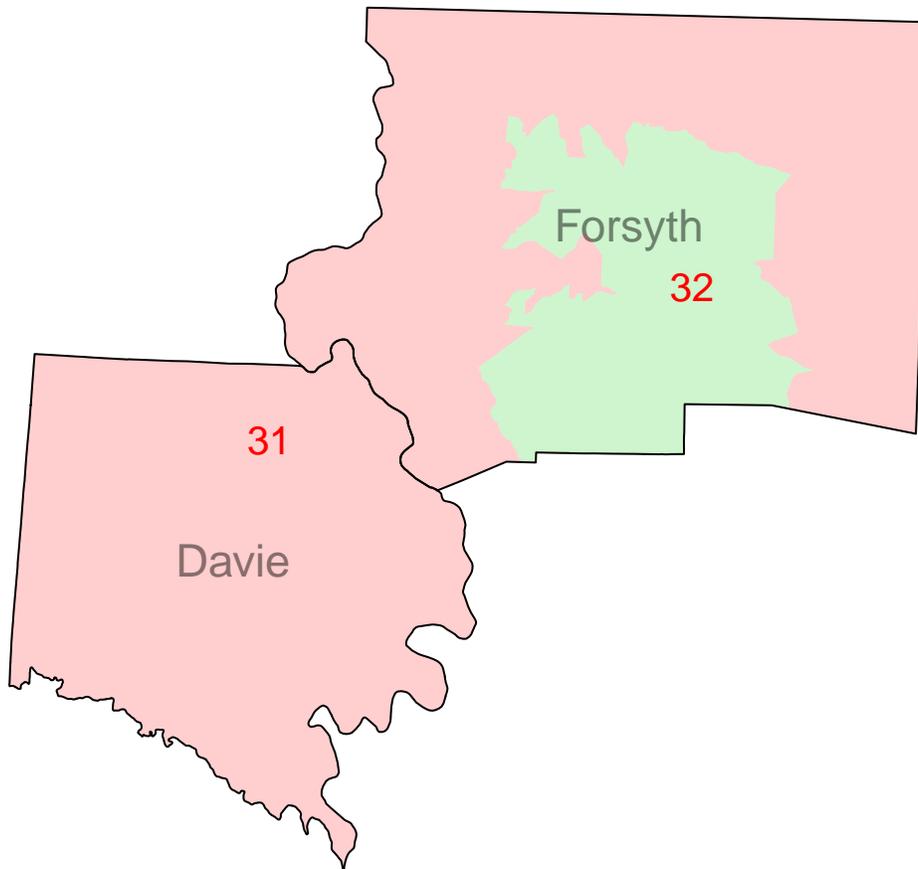
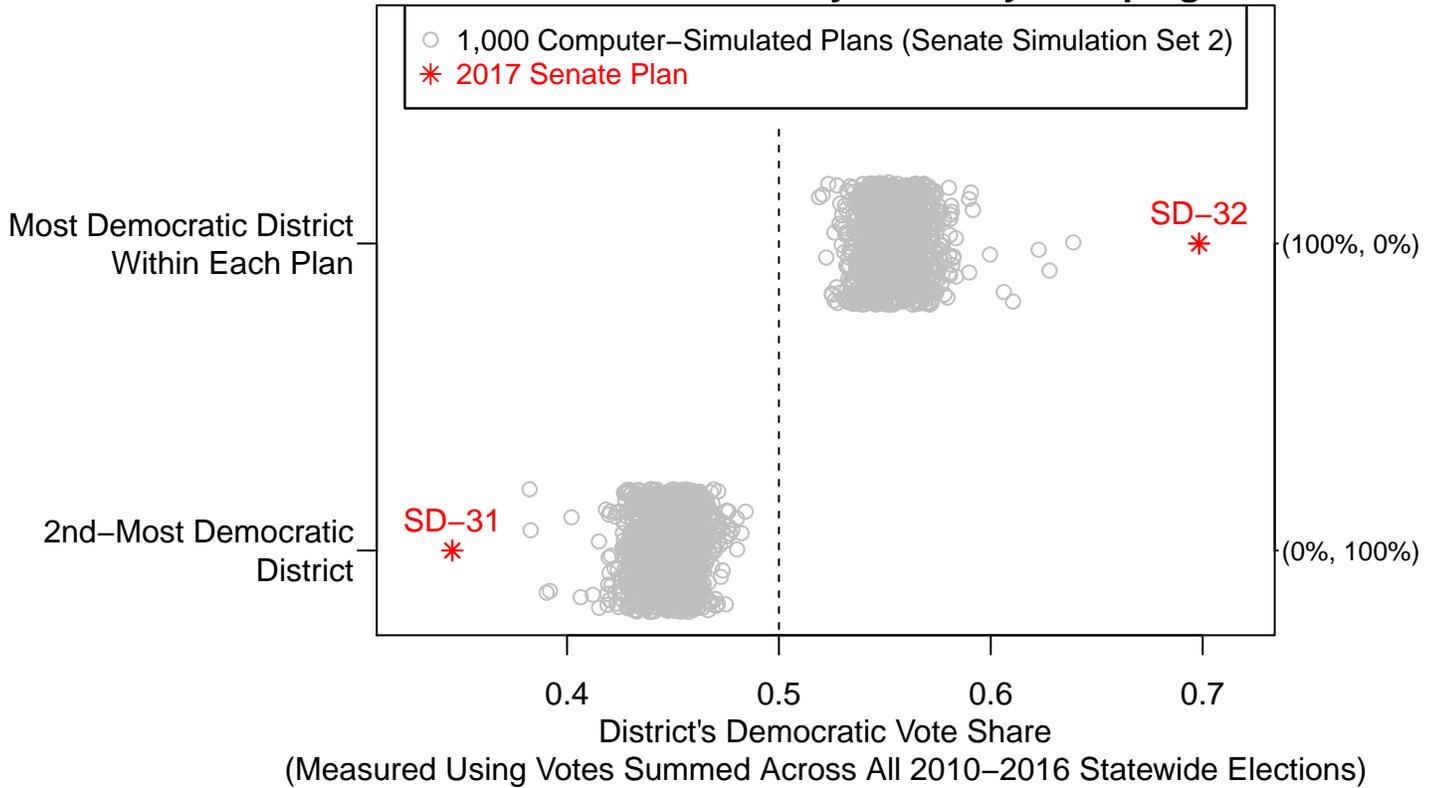


(Measured Using Votes Summed Across All 2010–2016 Statewide Elections)



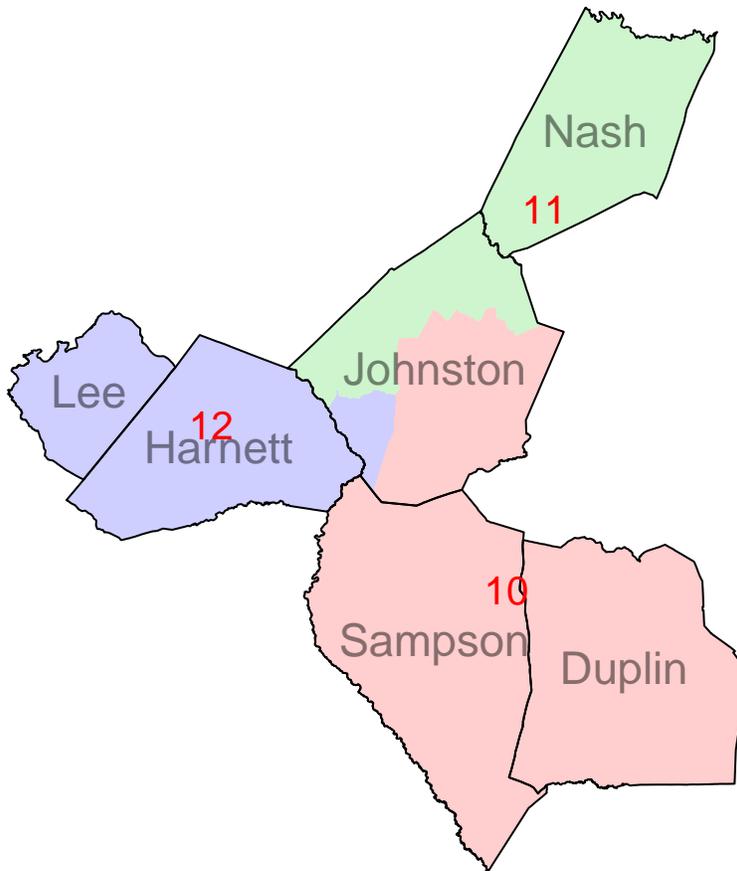
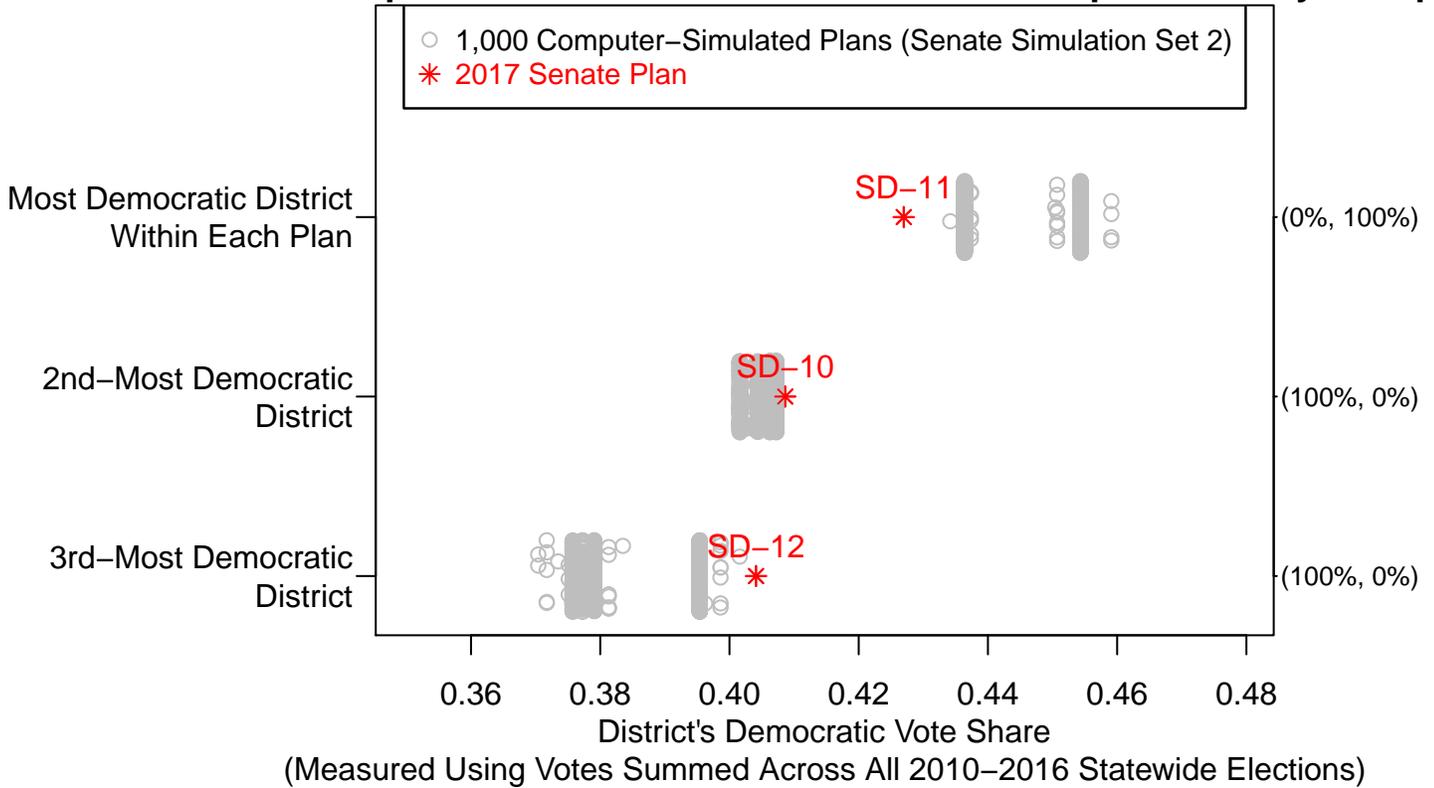
2017 Enacted Senate Plan Districts Within County Grouping 1
(Contains 4 districts, including 2 Special Master Districts (SD-24 and SD-28)
that are frozen in all simulated plans and included in the above Figure)

**Figure 82: Senate Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Davie-Forsyth County Grouping**



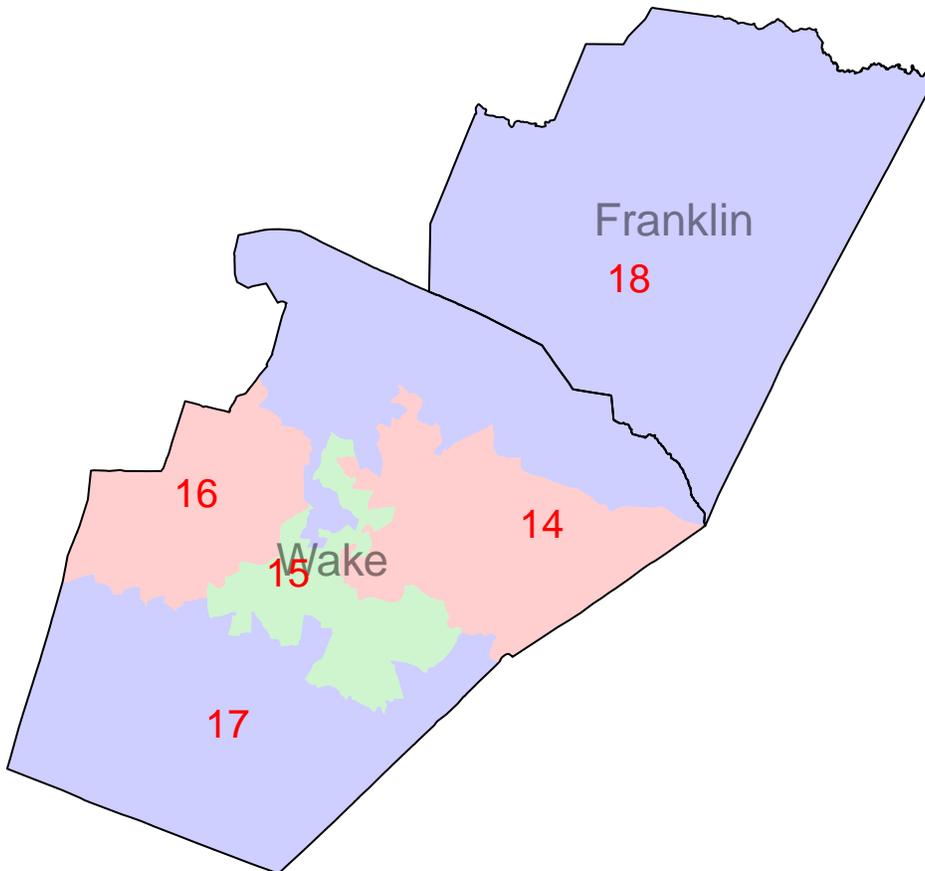
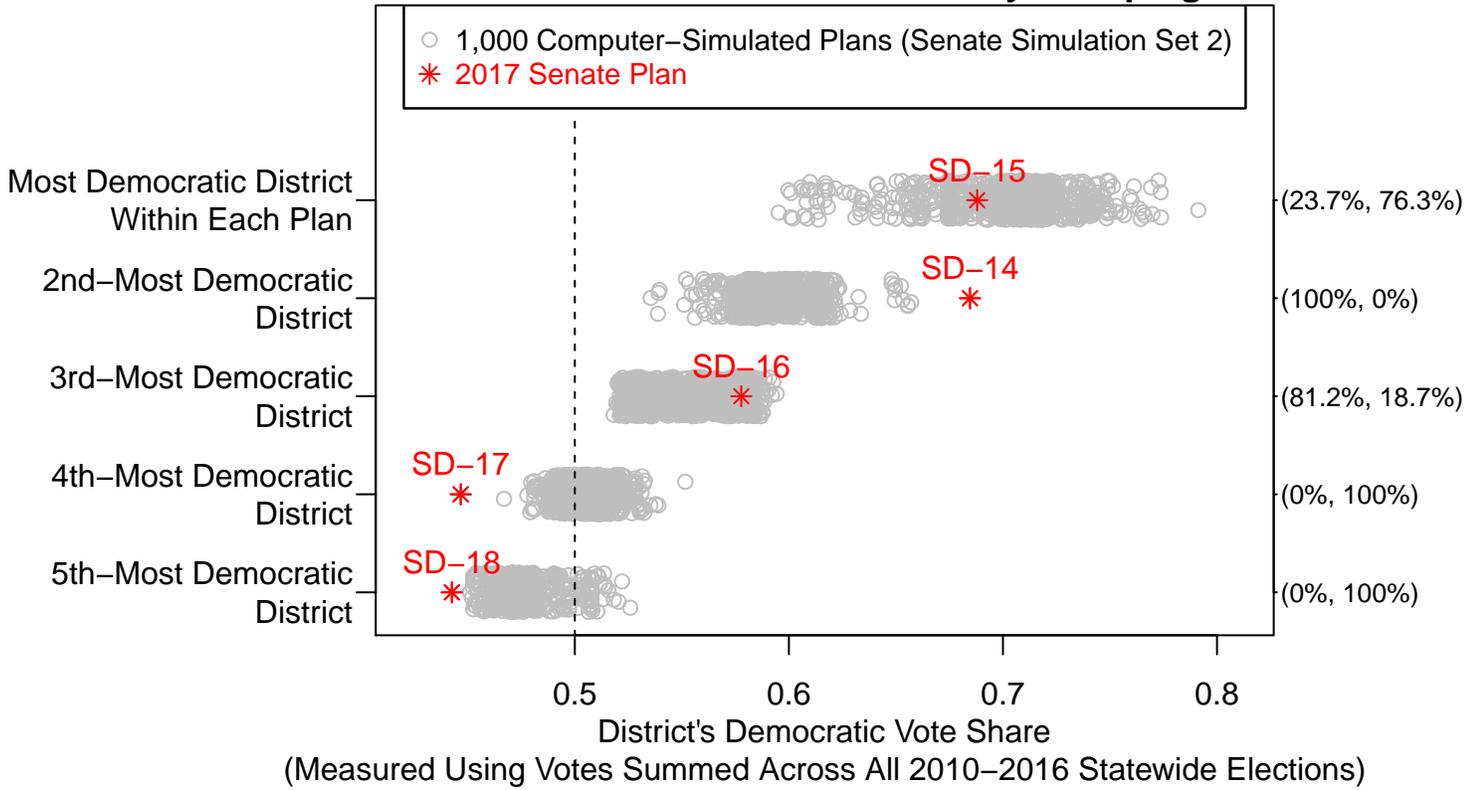
2017 Enacted Senate Plan Districts Within County Grouping 18 (Contains 2 Districts)

**Figure 83: Senate Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Duplin-Harnett-Johnston-Lee-Nash-Sampson County Grouping**



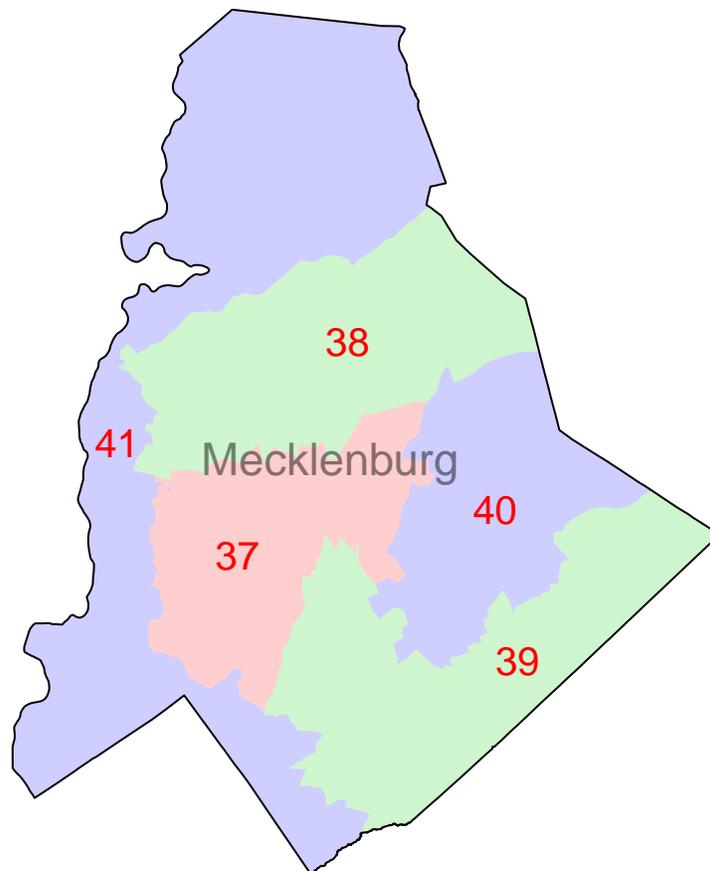
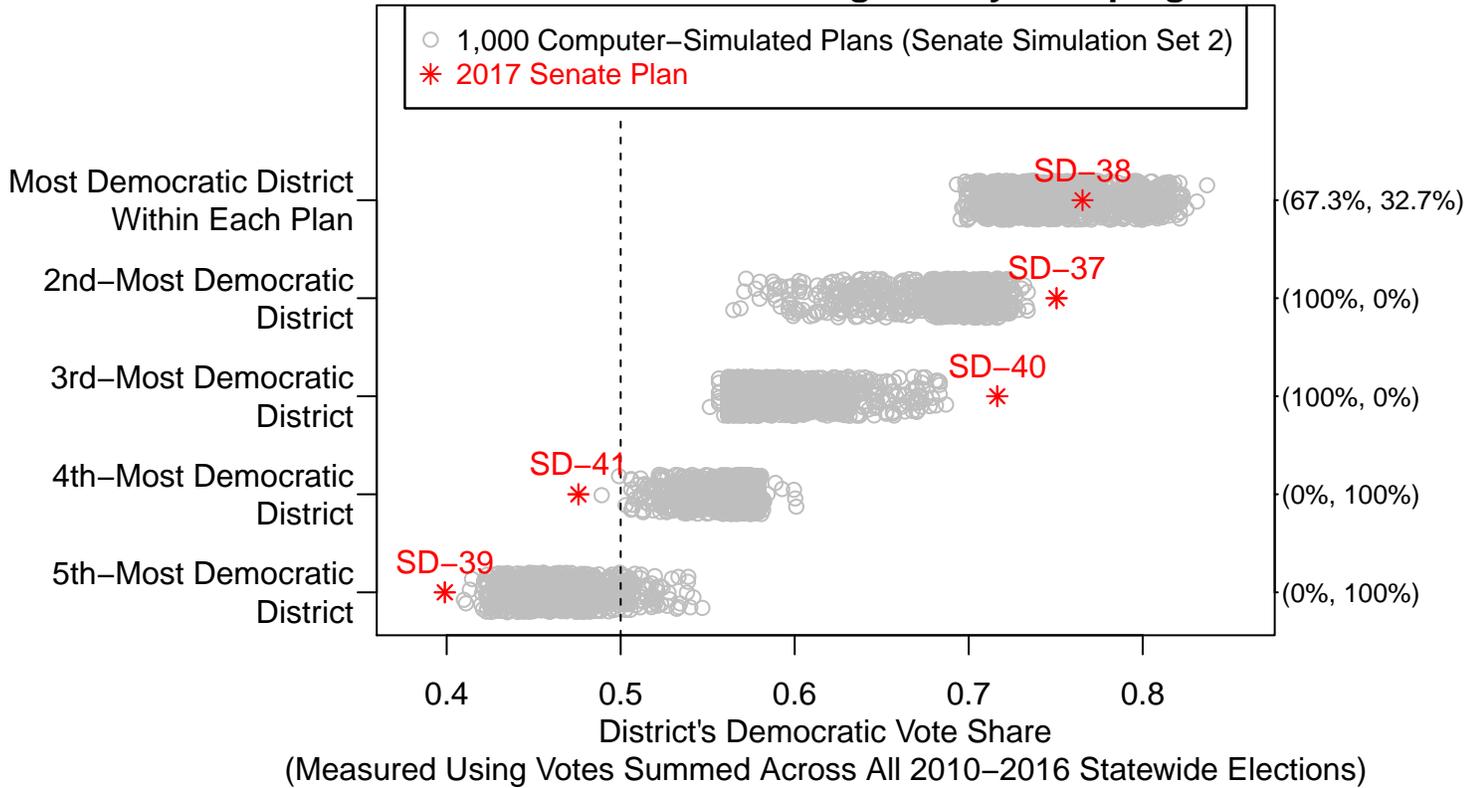
2017 Enacted Senate Plan Districts Within County Grouping 19 (Contains 3 Districts)

**Figure 84: Senate Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Franklin-Wake County Grouping**



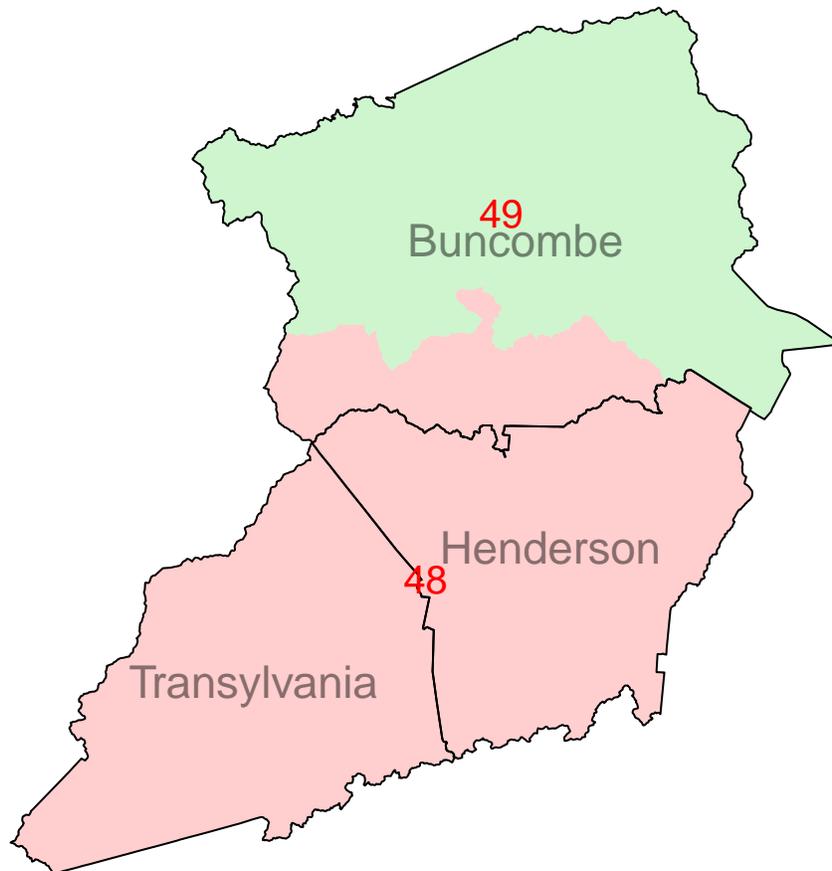
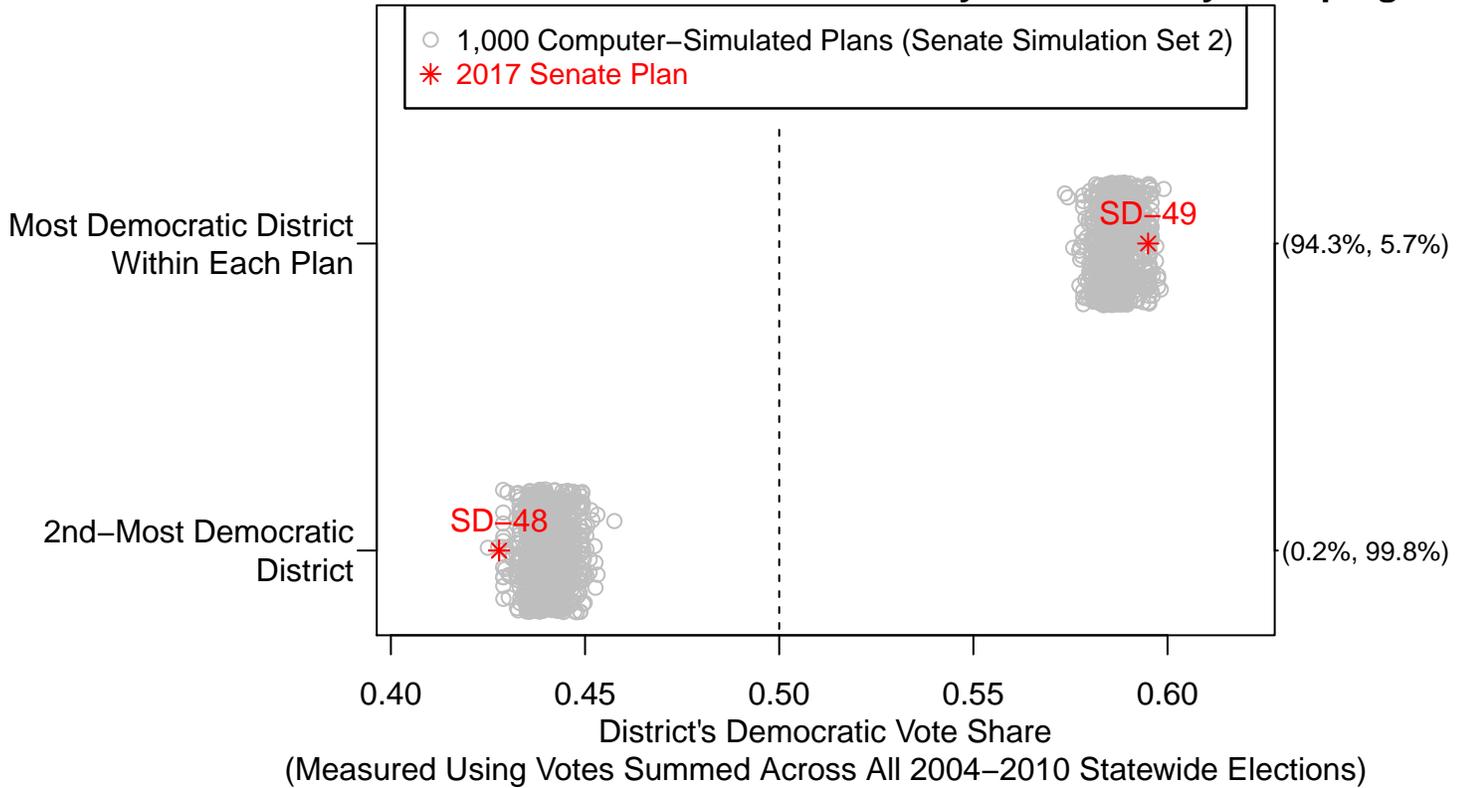
2017 Enacted Senate Plan Districts Within County Grouping 22 (Contains 5 Districts)

**Figure 85: Senate Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Mecklenburg County Grouping**



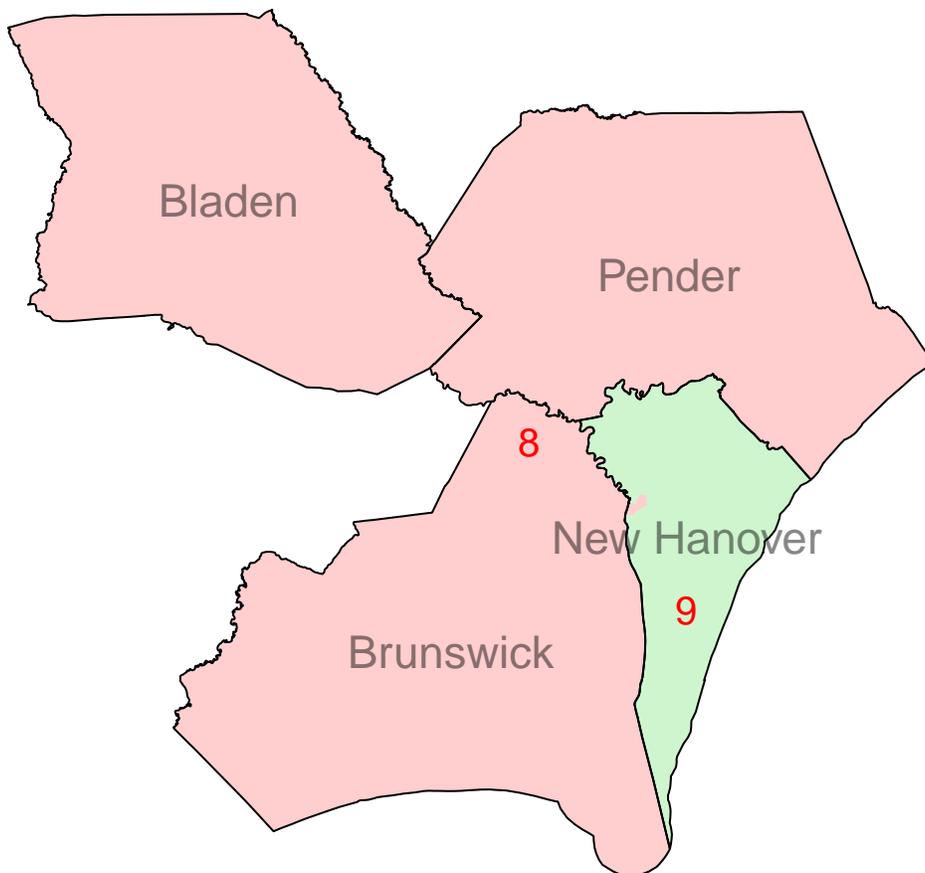
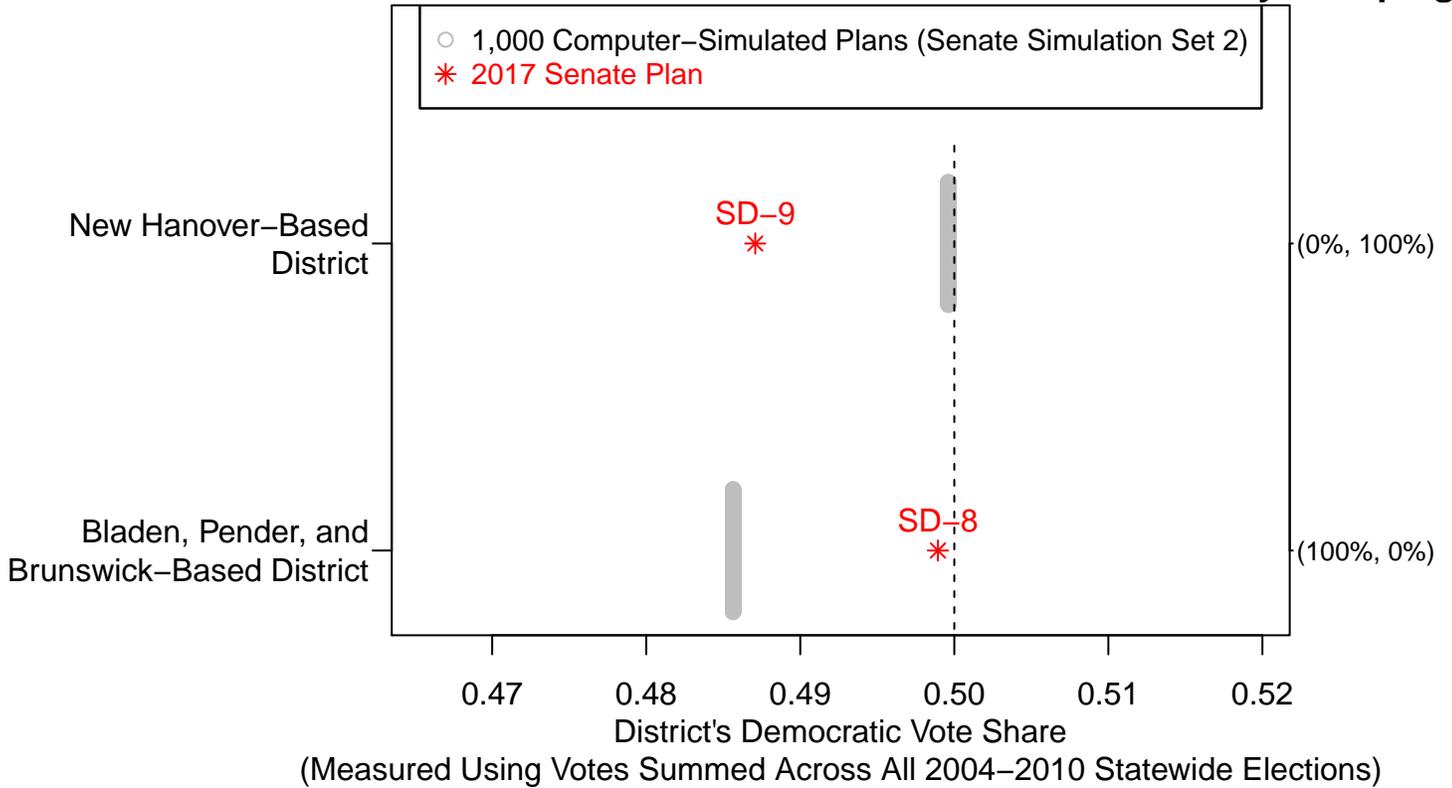
2017 Enacted Senate Plan Districts Within County Grouping 28 (Contains 5 Districts)

**Figure 86: Senate Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Buncombe-Henderson-Transylvania County Grouping**



2017 Enacted Senate Plan Districts Within County Grouping 8 (Contains 2 Districts)

**Figure 87: Senate Simulation Set 2:
Democratic Vote Share of the Enacted and Computer-Simulated Districts
Within the Bladen-Brunswick-New Hanover-Pender County Grouping**



2017 Enacted Senate Plan Districts Within County Grouping 7 (Contains 2 Districts)

Comparing the Number of Threshold-Level Republican Districts in the Enacted and Simulated Plans: The second approach I use is the same as the second approach used for the House: Within each county grouping, I consider all of the 2017 Senate Plan districts in the grouping that are Republican-leaning (with over a 50% Republican vote share), and I identify the most minimally Republican-leaning of these enacted districts. For both the 2017 Senate Plan and each of the computer-simulated Senate plans, I then compare the number of districts within the grouping that are at least as Republican-leaning as the most minimally Republican-leaning district within that grouping in the 2017 Senate Plan.

Figure 91 illustrates an example of this approach, analyzing the Franklin and Wake County grouping in the 2017 Senate Plan, which contains three districts (SD-14, SD-15, SD-16, SD-17, and SD-18). Two of these five districts are Republican-leaning, as measured using the 2010-2016 Statewide Election Composite. Among these two Republican-leaning districts, SD-17, with a Republican vote share of 55.33%, is the most minimally Republican-leaning of these districts. Therefore, I use this 55.33% Republican vote share threshold, and I count the number of districts in the 2017 Senate Plan and in the computer-simulated plans within this county grouping that are at least as heavily Republican as SD-17's Republican vote share of 55.33%.

The two histograms in Figure 91 illustrate the results of this analysis of the Franklin and Wake County grouping. The 2017 Senate Plan contains two districts (SD-17 and SD-18) that are at least as Republican as SD-17's Republican vote share of 55.33%. The left histogram in Figure 91 reveals that every single one of the 1,000 simulated plans in Senate Simulation Set 1 contains zero districts in this county grouping with at least a 55.33% Republican vote share. Similarly, the right histogram in Figure 91 also illustrates that every one of the 1,000 simulated plans in Senate Simulation Set 2 contains zero districts in this county grouping with at least a 55.33% Republican vote share. Not a single one of these 2,000 computer-simulated plans contains two such Republican districts. Therefore, the 2017 Senate Plan is a statistical outlier within the Franklin and Wake County grouping in its creation of two Republican districts with at least a 55.33% Republican vote share.

I use this same approach to analyze each 2017 Senate Plan districts within different county groupings. Figures 88 to 94 each focus on a single county grouping, with the left histogram analyzing Senate Simulation Set 1 plans and the right histogram analyzing Senate Simulation Set 2. As before, for county groupings containing districts that were originally drawn

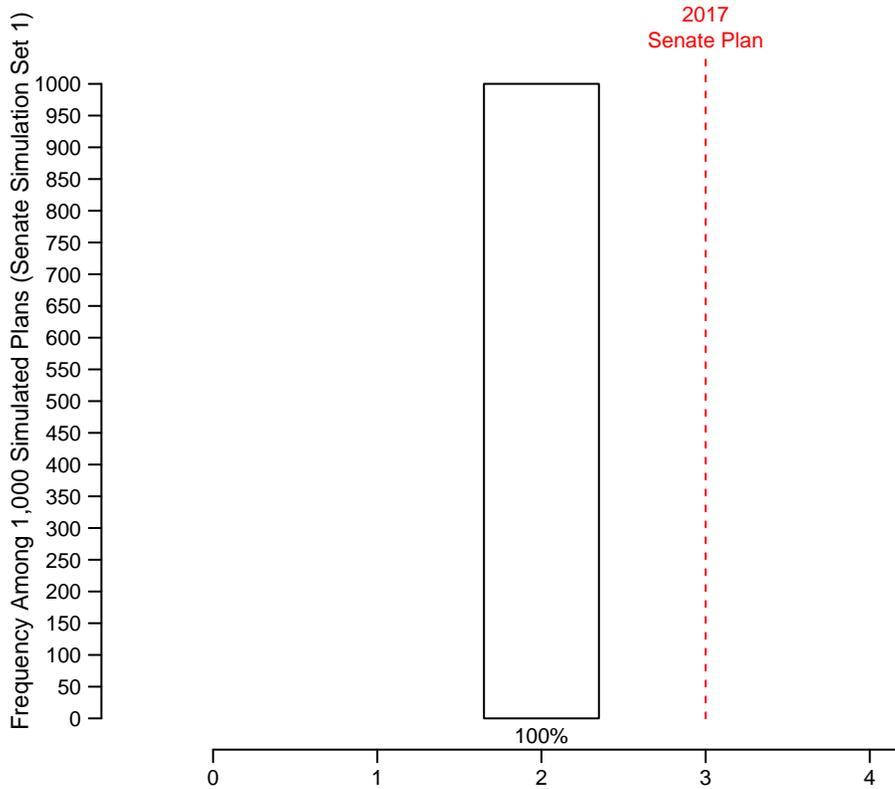
in 2011 and remained unchanged in the 2017 redistricting process, I used the 2004-2010 Statewide Election Composite to measure district partisanship in these Figures, since the 2004-2010 statewide elections represent the elections data available to and used by the General Assembly during the 2011 redistricting process.

Overall, using this partisan threshold methodology, I found that the 2017 Senate plan creates partisan outliers within the following seven Senate county groupings:

1. The Alamance-Guilford-Randolph County grouping (Figure 88).
2. The Bladen-Brunswick-New Hanover -Pender County grouping (Figure 93).
3. The Buncombe-Henderson-Transylvania County grouping (Figure 94).
4. The Davie-Forsythe County grouping (Figure 89).
5. The Duplin-Harnett-Johnston-Lee-Nash-Sampson County grouping (Figure 90).
6. The Franklin-Wake County grouping (Figure 91).
7. The Mecklenburg County grouping (Figure 92).

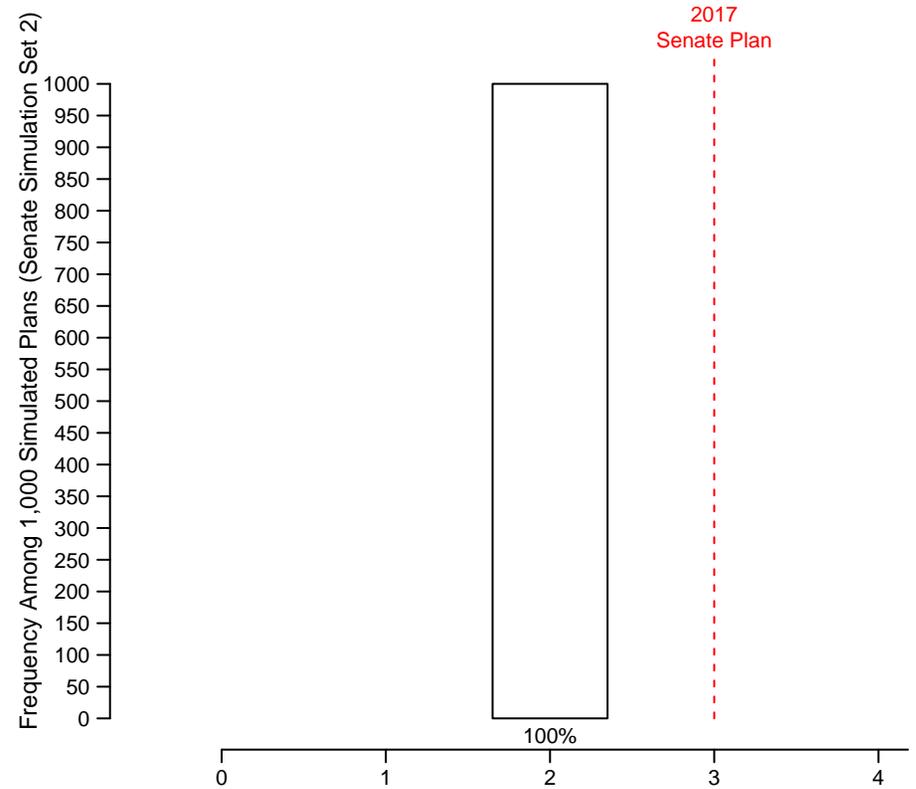
**Figure 88:
Number of Senate Districts With At Least SD-27's Republican Vote Share of 55.38% in the
Alamance-Guilford-Randolph County Grouping**

Simulation Set 1



Number of Districts With At Least SD-27's Republican Vote Share of 55.38% in the Alamance-Guilford-Randolph County Grouping (Measured Using Votes Summed Across 2010-2016 Statewide Elections)

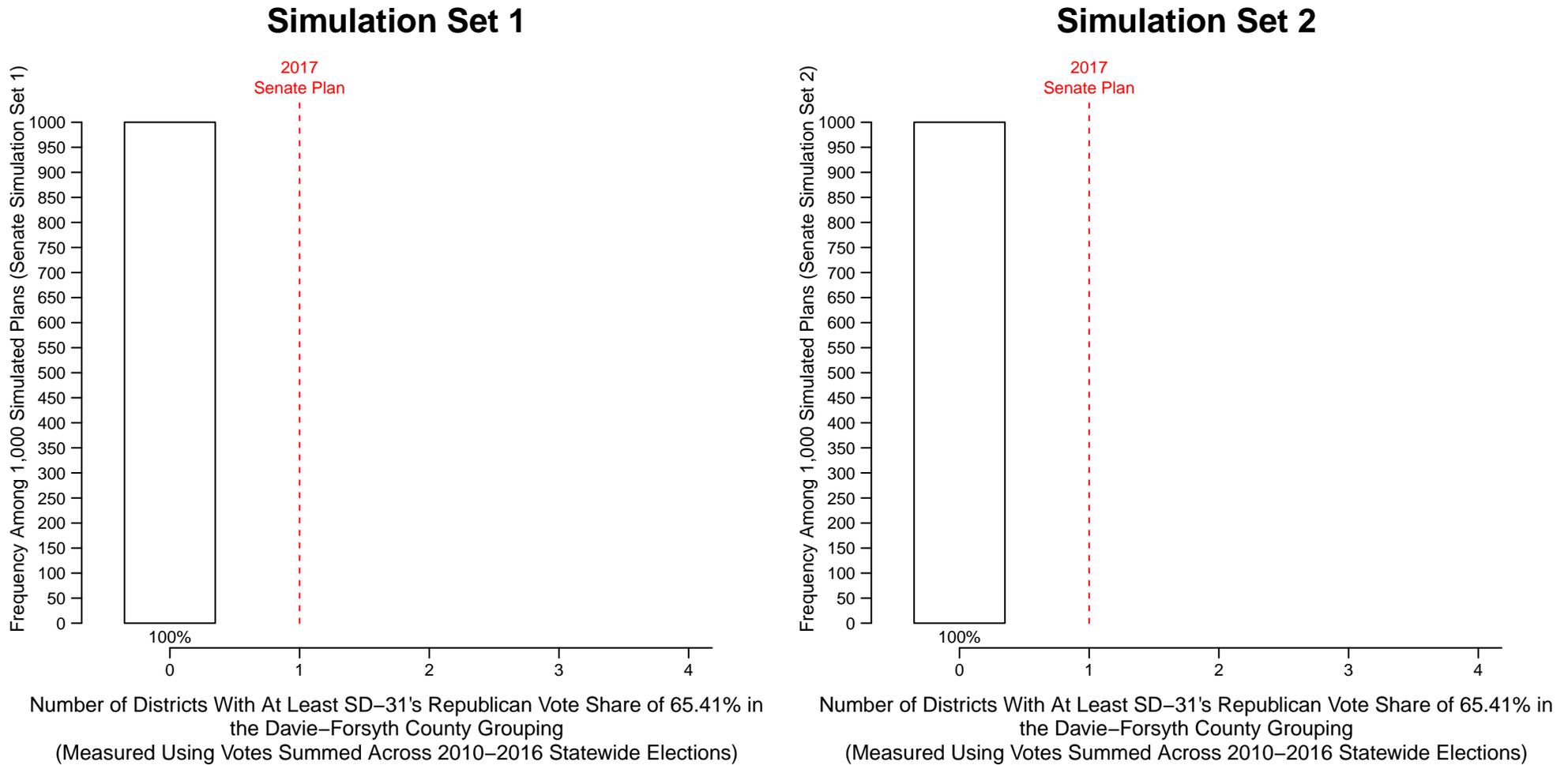
Simulation Set 2



Number of Districts With At Least SD-27's Republican Vote Share of 55.38% in the Alamance-Guilford-Randolph County Grouping (Measured Using Votes Summed Across 2010-2016 Statewide Elections)

Note: The Alamance-Guilford-Randolph County Grouping includes the following 2017 Senate Plan districts: 24; 26; 27; 28
The Special Master-drawn districts are INCLUDED in this Figure (Including SD-24, a 56.8% Republican district).

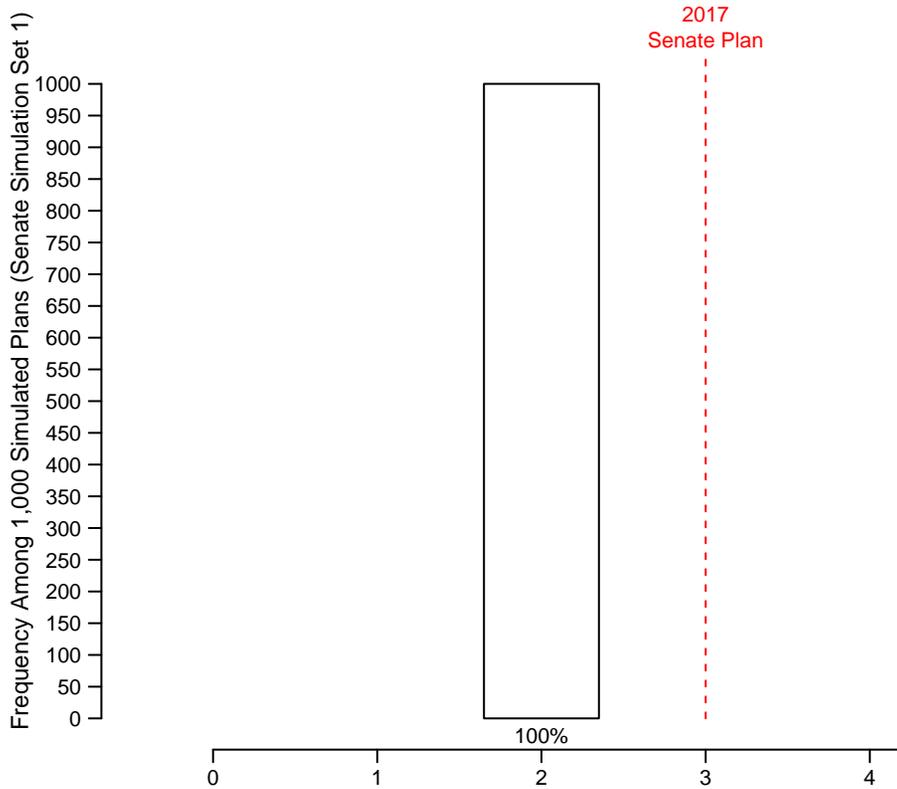
**Figure 89:
Number of Senate Districts With At Least SD-31's Republican Vote Share of 65.41% in the
Davie-Forsyth County Grouping**



Note: The Davie-Forsyth County Grouping includes the following 2017 Senate Plan districts: 31; 32

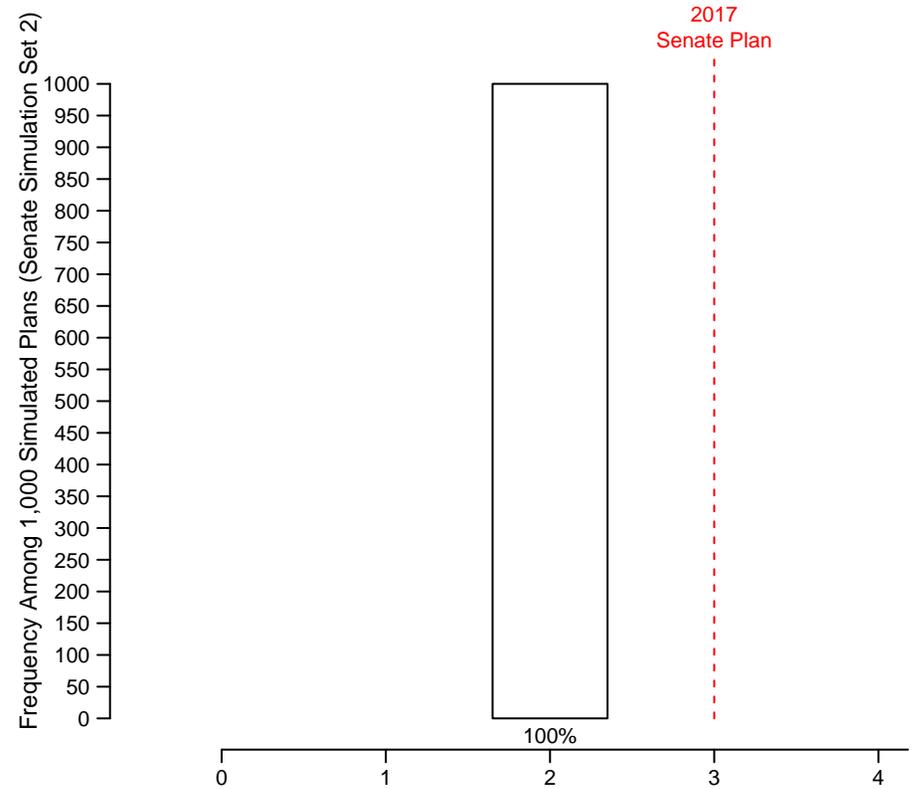
**Figure 90:
Number of Senate Districts With At Least SD-11's Republican Vote Share of 57.3% in the
Duplin-Harnett-Johnston-Lee-Nash-Sampson County Grouping**

Simulation Set 1



Number of Districts With At Least SD-11's Republican Vote Share of 57.3% in the Duplin-Harnett-Johnston-Lee-Nash-Sampson County Grouping (Measured Using Votes Summed Across 2010-2016 Statewide Elections)

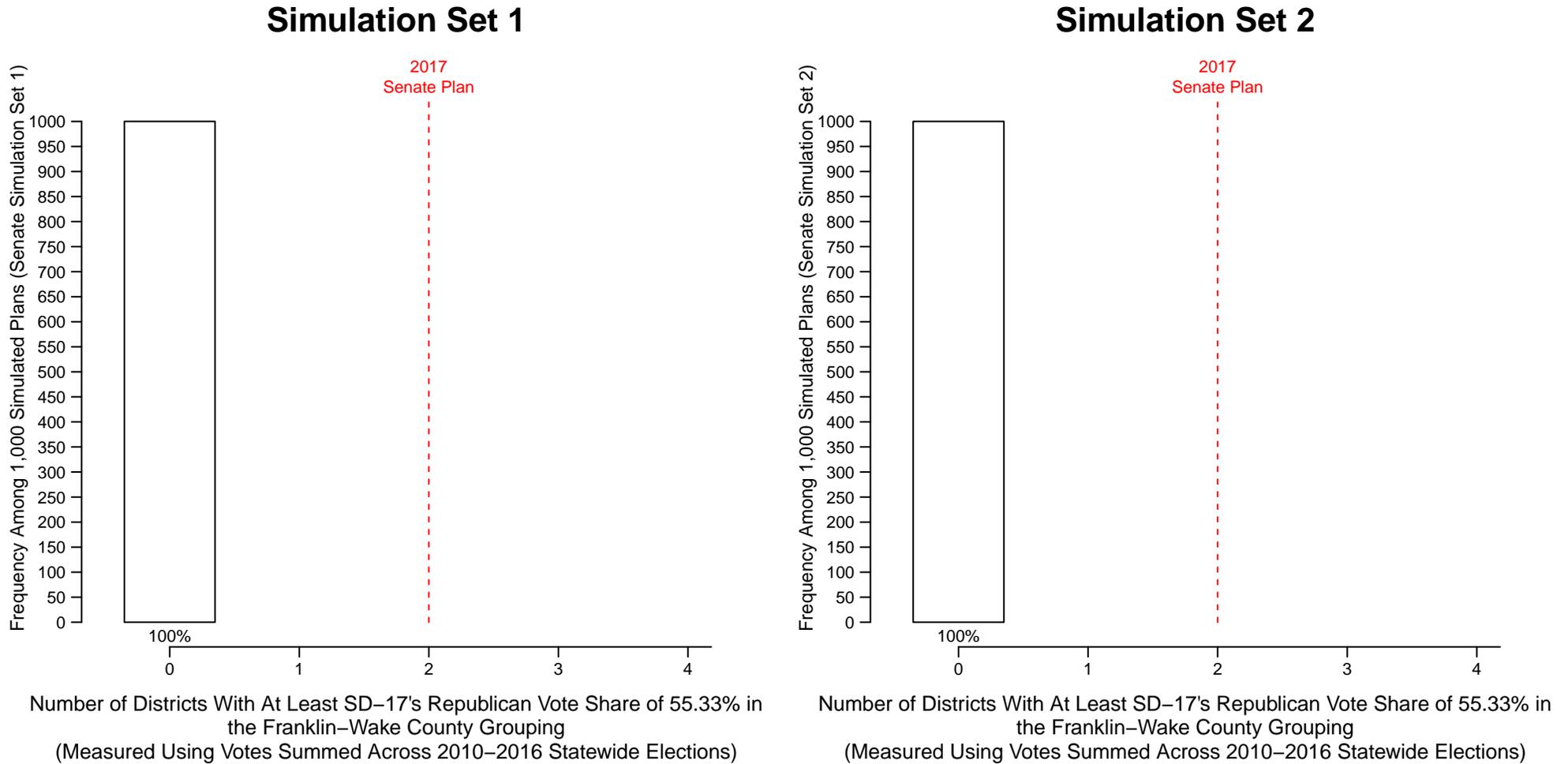
Simulation Set 2



Number of Districts With At Least SD-11's Republican Vote Share of 57.3% in the Duplin-Harnett-Johnston-Lee-Nash-Sampson County Grouping (Measured Using Votes Summed Across 2010-2016 Statewide Elections)

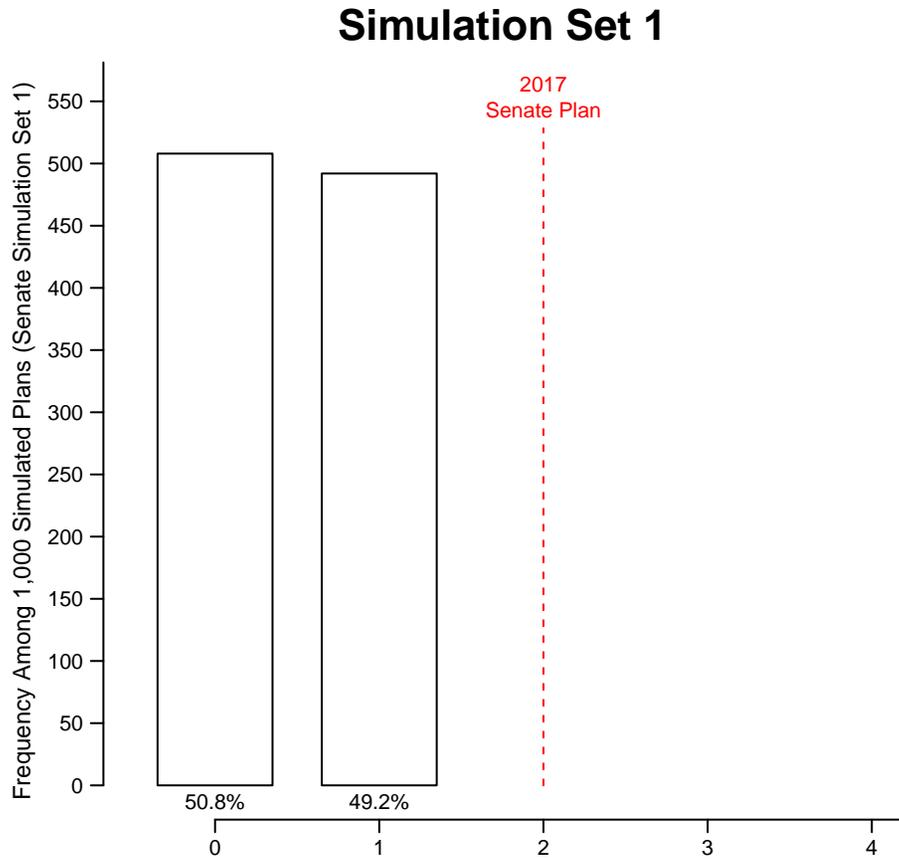
Note: The Duplin-Harnett-Johnston-Lee-Nash-Sampson County Grouping includes the following 2017 Senate Plan districts: 10; 11; 12

**Figure 91:
Number of Senate Districts With At Least SD-17's Republican Vote Share of 55.33% in the Franklin-Wake County Grouping**

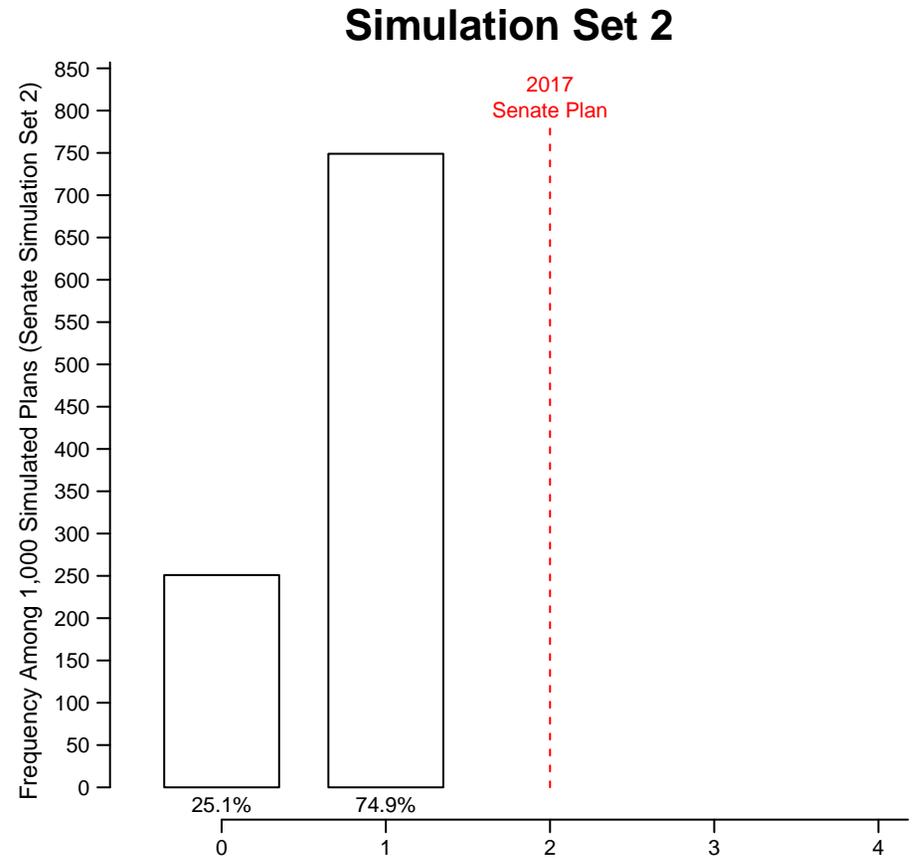


Note: The Franklin-Wake County Grouping includes the following 2017 Senate Plan districts: 14; 15; 16; 17; 18

**Figure 92:
Number of Senate Districts With At Least SD-41's Republican Vote Share of 52.43% in the
Mecklenburg County Grouping**



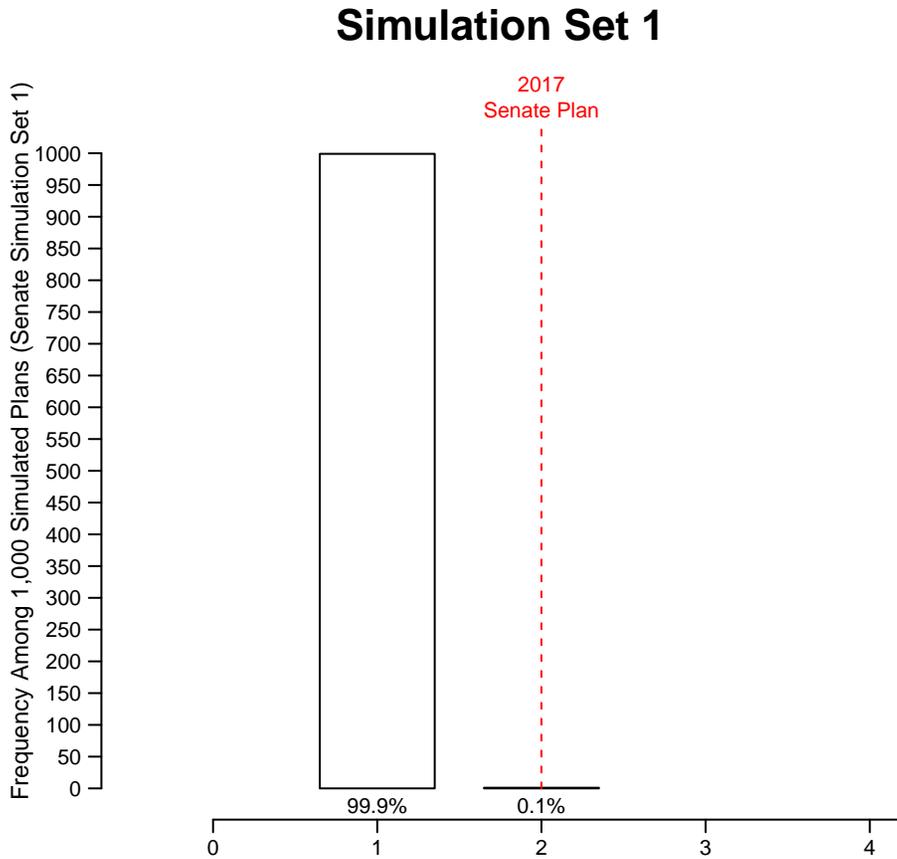
Number of Districts With At Least SD-41's Republican Vote Share of 52.43% in the Mecklenburg County Grouping
(Measured Using Votes Summed Across 2010–2016 Statewide Elections)



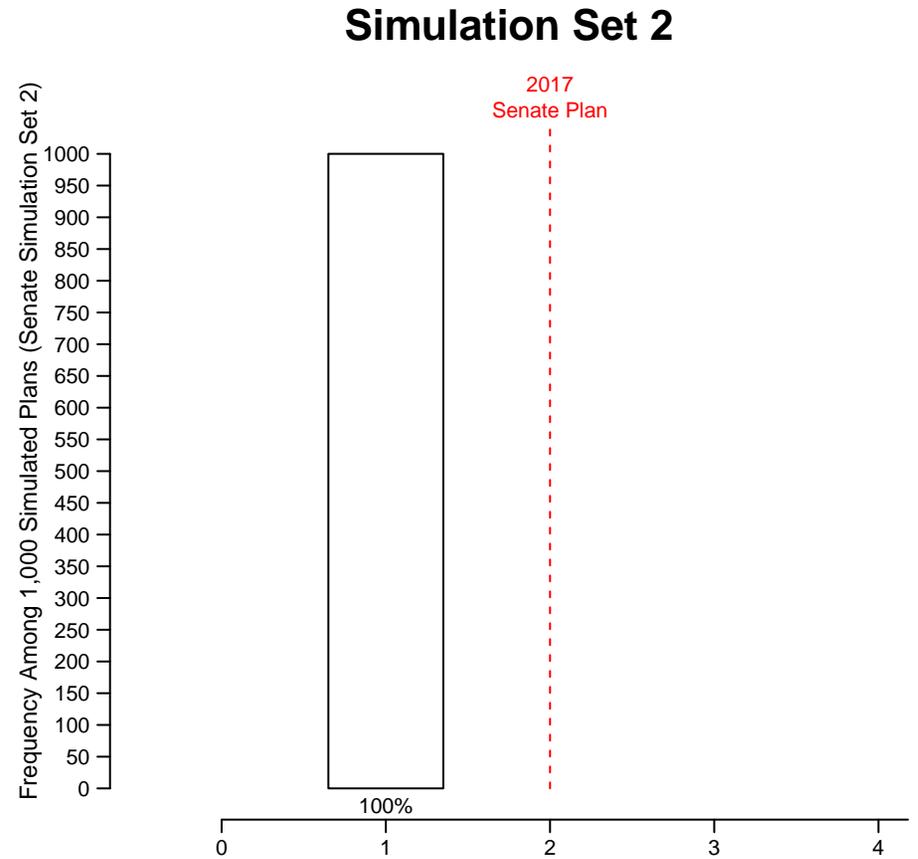
Number of Districts With At Least SD-41's Republican Vote Share of 52.43% in the Mecklenburg County Grouping
(Measured Using Votes Summed Across 2010–2016 Statewide Elections)

Note: The Mecklenburg County Grouping includes the following 2017 Senate Plan districts: 37; 38; 39; 40; 41

**Figure 93:
Number of Senate Districts With At Least SD-8's Republican Vote Share of 50.11% in the
Bladen-Brunswick-New Hanover-Pender County Grouping**



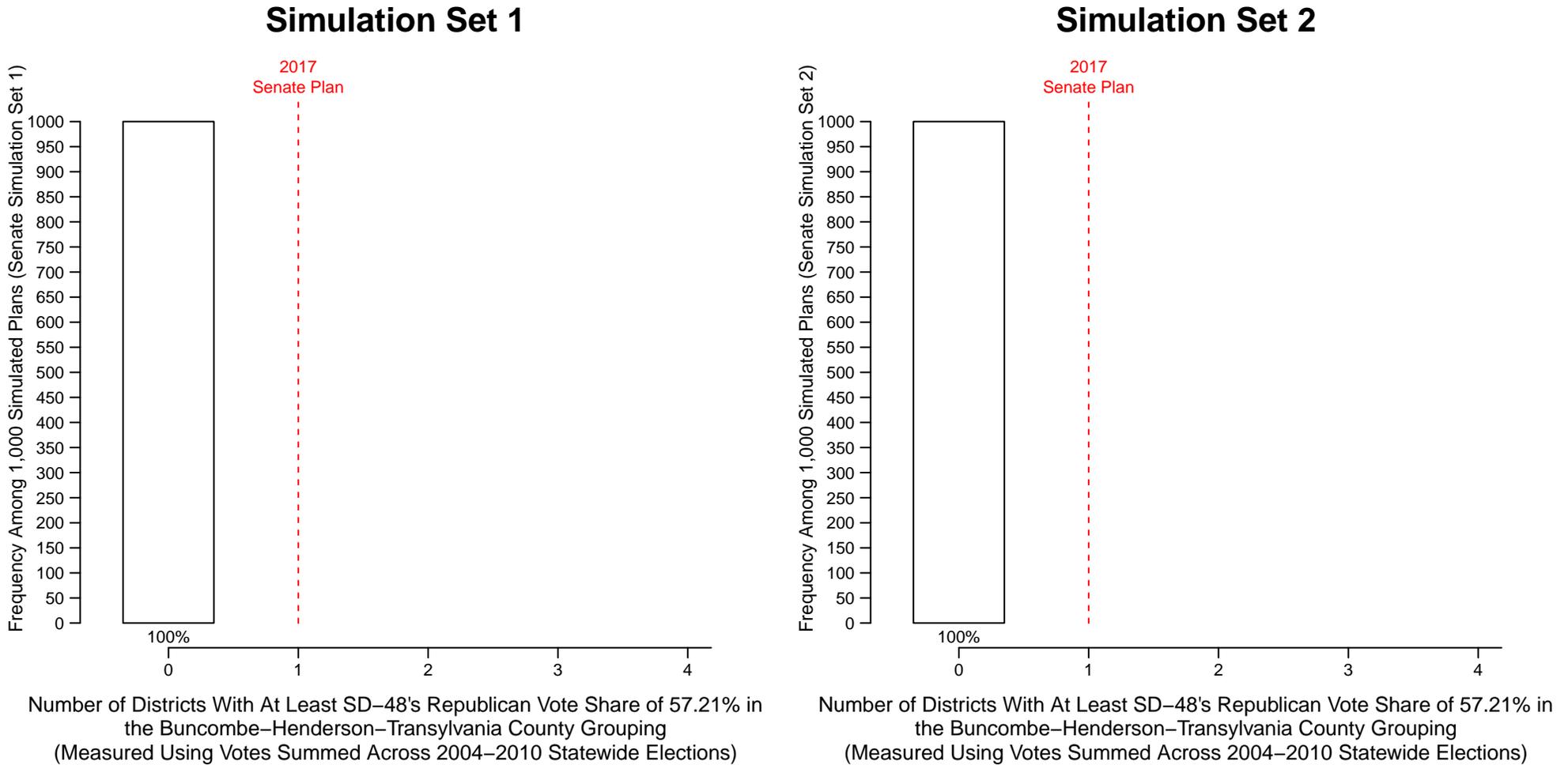
Number of Districts With At Least SD-8's Republican Vote Share of 50.11% in the Bladen-Brunswick-New Hanover-Pender County Grouping (Measured Using Votes Summed Across 2004-2010 Statewide Elections)



Number of Districts With At Least SD-8's Republican Vote Share of 50.11% in the Bladen-Brunswick-New Hanover-Pender County Grouping (Measured Using Votes Summed Across 2004-2010 Statewide Elections)

Note: The Bladen-Brunswick-New Hanover-Pender County Grouping includes the following 2017 Senate Plan districts: 8; 9

**Figure 94:
Number of Senate Districts With At Least SD-48's Republican Vote Share of 57.21% in the
Buncombe–Henderson–Transylvania County Grouping**



Note: The Buncombe–Henderson–Transylvania County Grouping includes the following 2017 Senate Plan districts: 48; 49

Analysis of Plaintiffs' Districts in the Enacted Plans and the Computer-Simulated Plans

As an additional method of evaluating the actual partisan effect of the 2017 House Plan and the 2017 Senate Plan on the individual plaintiffs in this case, I evaluate the sort of House and Senate districts each plaintiff would have been placed into under the 4,000 computer-simulated plans, compared to the plaintiffs' actual districts under the enacted 2017 House and Senate Plans. Plaintiffs' counsel provided to me a list of the individual plaintiffs, along with their respective geocoded residential addresses. I used these addresses in order to identify the specific district that each plaintiff would have been located in under each computer-simulated plan, as well as under the 2017 House Plan and 2017 Senate Plan. For those plaintiffs who live in House or Senate districts that are within the selected county groupings I analyzed above, I analyze the partisan characteristics of the districts each plaintiff would typically have been districted into under the simulated plans. Figures 95 to 98 present the results of this analysis. These Figures each list the individual plaintiffs and describe the partisanship of each plaintiff's district of residence in the 2017 House Plan or Senate Plan, as well as in one of the sets of 1,000 simulated districting plans presented in this report. Specifically, Figure 95 describes each plaintiff's district of residence in the 2017 House Plan and compares it to the district the plaintiff would have resided in under each of the 1,000 simulated plans in House Simulation Set 1. Figure 96 describes each plaintiff's district of residence in the 2017 House Plan and compares it to the district the plaintiff would have resided in under each of the 1,000 simulated plans in House Simulation Set 2. Figure 97 describes each plaintiff's district of residence in the 2017 Senate Plan and compares it to the district the plaintiff would have resided in under each of the 1,000 simulated plans in Senate Simulation Set 1. And finally, Figure 98 describes each plaintiff's district of residence in the 2017 Senate Plan and compares it to the district the plaintiff would have resided in under each of the 1,000 simulated plans in Senate Simulation Set 2.

To explain these analyses with an example, Figure 95, which compares plaintiffs' districts in the 2017 House Plan to their districts under House Simulation Set 1 plans, is organized as follows: Each row in Figure 95 corresponds to a particular individual plaintiff. In the second row, describing plaintiff Vinod Thomas, the red star depicts the partisanship of the plaintiff's 2017 House Plan district (HD-98), as measured by Democratic vote share using the 2010-2016 Statewide Election Composite. The plaintiff's 2017 House Plan district number is also labeled in red, just above this red star. Finally, the 1,000 gray circles on this row depict the Democratic

vote share of each of the 1,000 simulated districts in which the plaintiff would have resided in each of the 1,000 simulated plans in House Simulation Set 1, based on that plaintiff's current home address. In the far right margin, to the right of each row, I list in parentheses how many of the 1,000 simulated plans would place the plaintiff in a more Republican-leaning district (on the left) and how many of the 1,000 simulations would place the plaintiff in a more Democratic-leaning district (on the right) than the plaintiff's 2017 House Plan district. Thus, for example, the second row of Figure 95 reports that 99.4% of the 1,000 computer-simulated plans in House Simulation Set 1 would have placed plaintiff Vinod Thomas in a more Democratic-leaning district than his actual 2017 House Plan district (HD-98). Only 0.6% of the simulations would have placed Vinod Thomas in a more Republican-leaning district. Therefore, using a standard threshold test of 95% for statistical significance, I can conclude that Vinod Thomas' 2017 House Plan district is a partisan statistical outlier when compared to Vinod Thomas' district under the 1,000 House Simulation Set 1 plans.

Hence, this Figure allows me to identify plaintiffs whose 2017 House Plan districts are partisan outliers compared to the computer-simulated districts in which the plaintiff would have been placed under House Simulation Set 1. I am also able to identify how the partisanship of the plaintiffs' districts would have been different under the simulated plans, as compared to under the 2017 House Plan.

In Figures 97 and 98, I perform the same analysis for the Senate districts that individual plaintiffs' would be placed into under the simulated Senate plans in Senate Simulation Set 1 and Senate Simulation Set 2. I compare the partisanship of the plaintiffs' districts under the 2017 Senate Plan to the partisanship of plaintiffs' districts under the 1,000 simulated plans in Senate Simulation Set 1 (Figure 97) and the 1,000 simulated plans in Senate Simulation Set 2 (Figure 98).

Figure 95: House Simulation Set 1

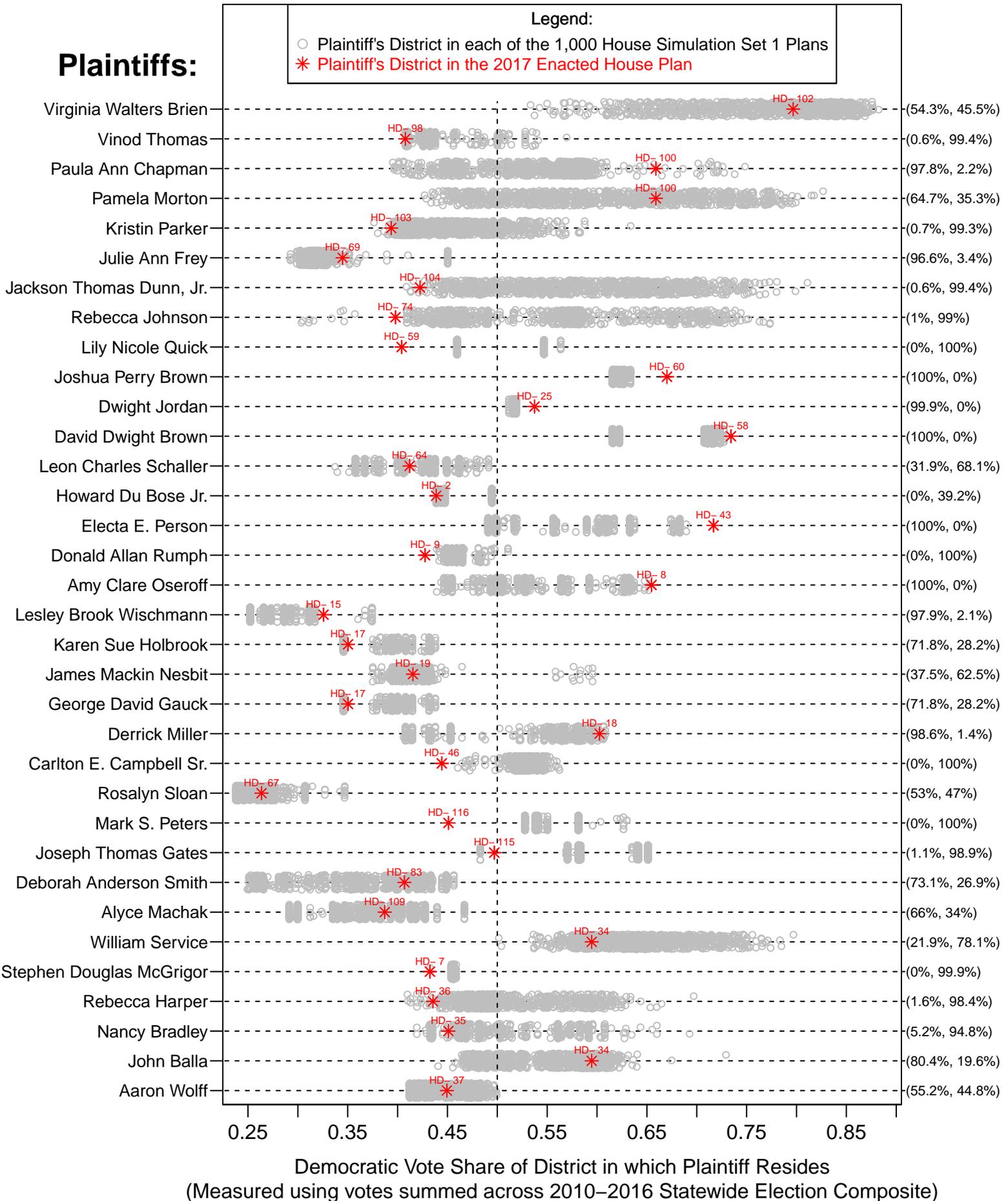


Figure 96: House Simulation Set 2

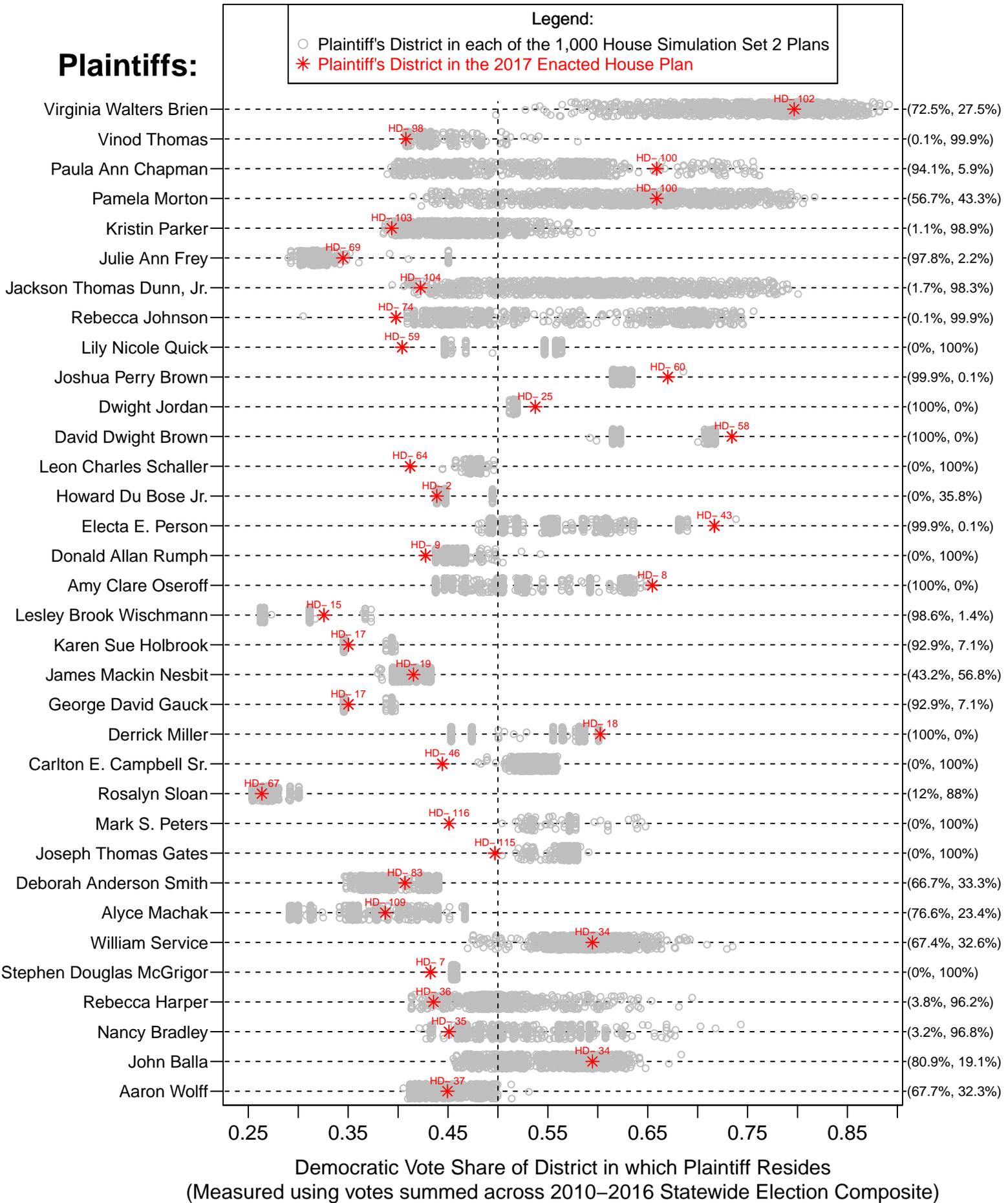


Figure 97: Senate Simulation Set 1

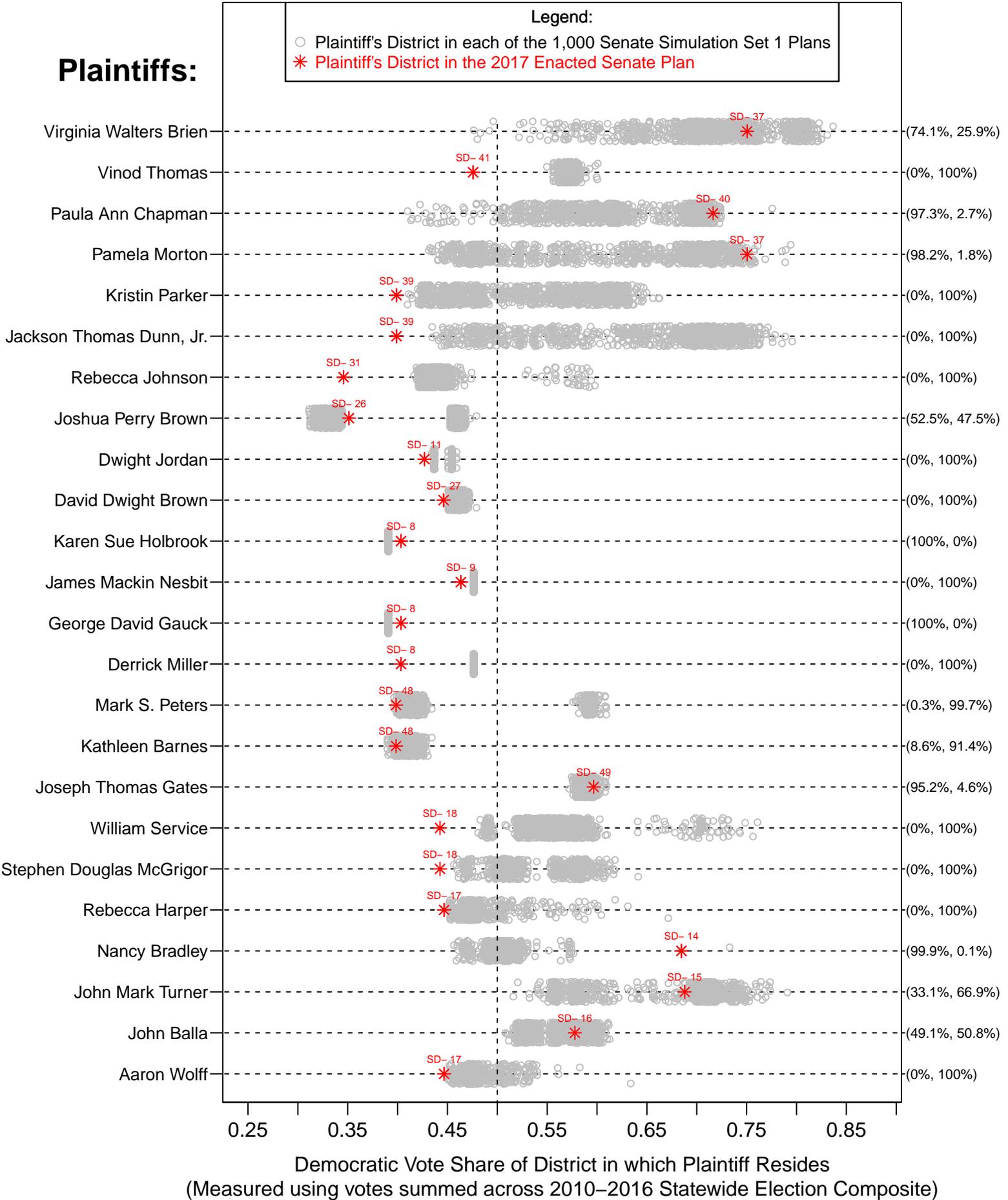


Figure 98: Senate Simulation Set 2



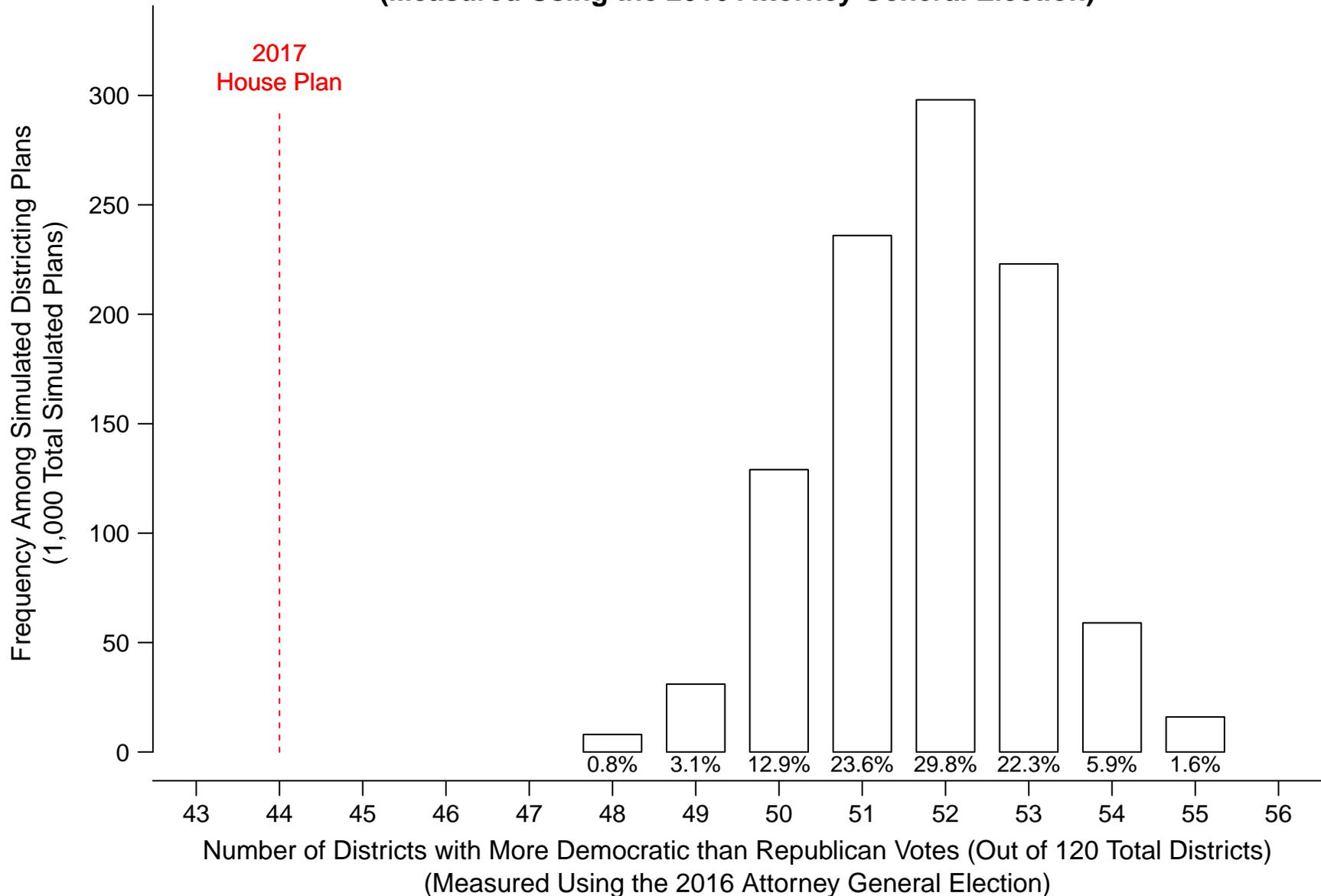
I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct to the best of my knowledge.

This 8th day of April, 2019.

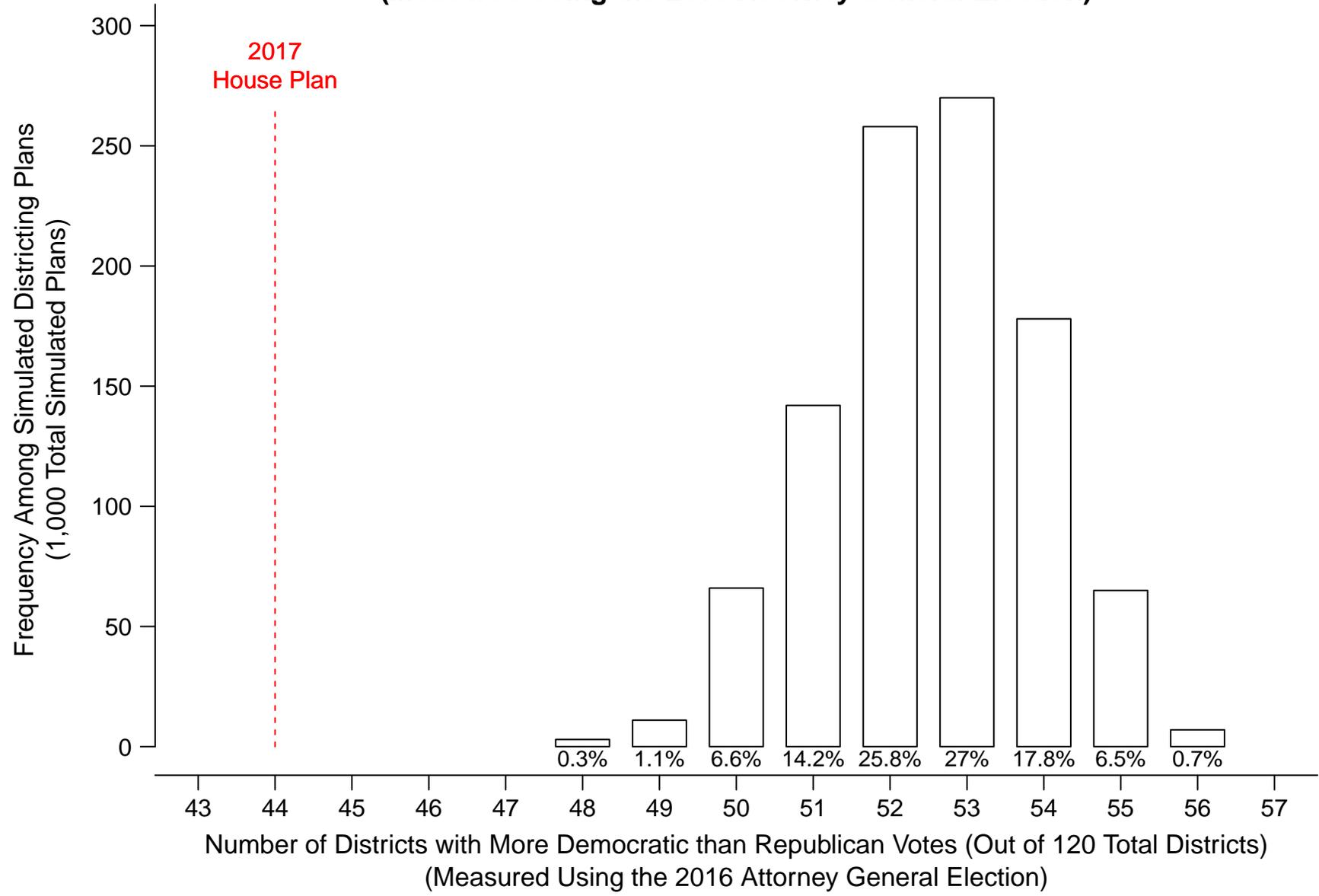
A handwritten signature in black ink, appearing to read "Jowei Chen", with a horizontal line underneath.

Jowei Chen

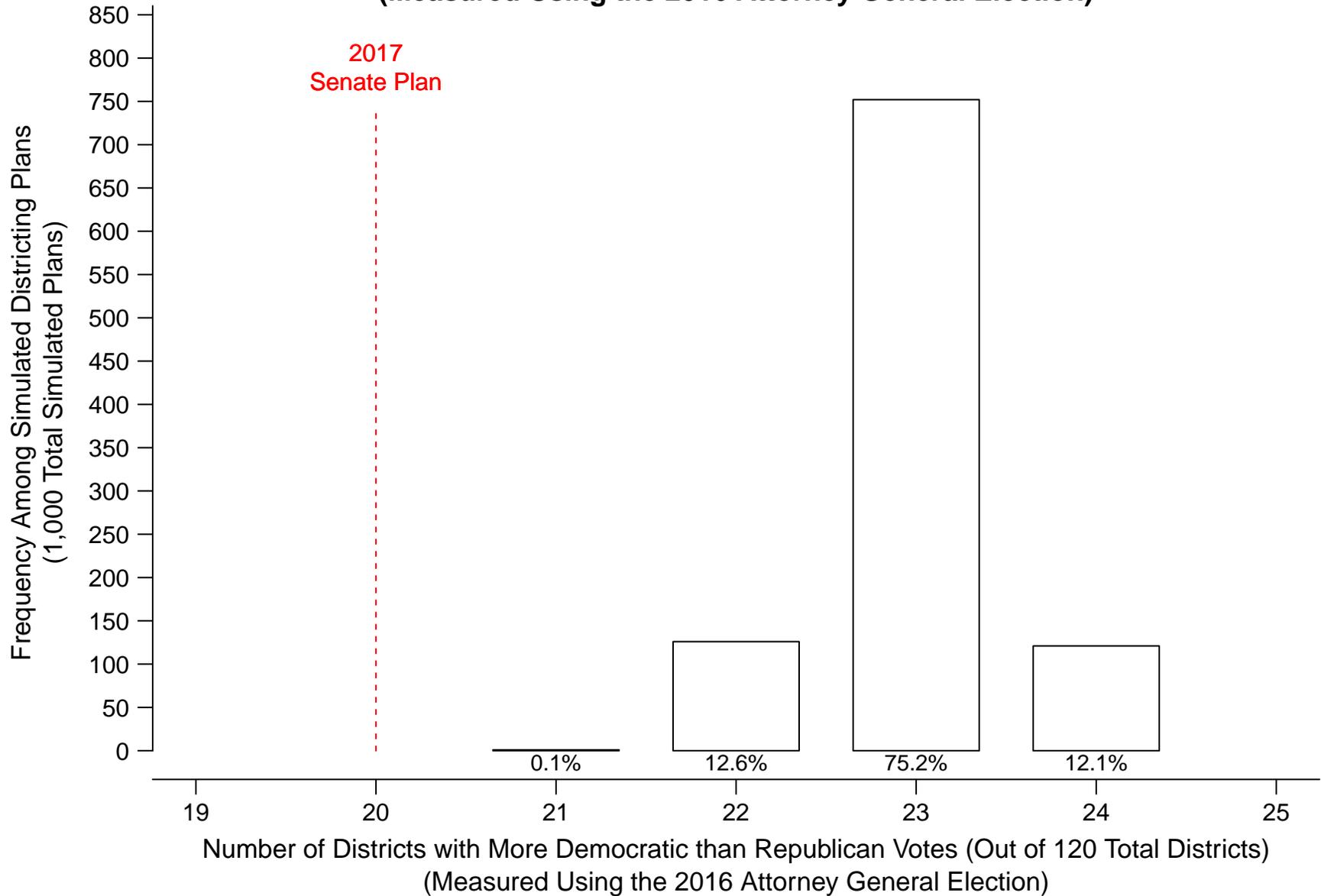
**Appendix A, Figure A1:
House Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Democratic-Favoring Districts in 2017 House Plan Versus 1,000 Simulated Plans
(Measured Using the 2016 Attorney General Election)**



**Appendix A, Figure A2:
 House Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Avoiding Incumbent Pairings):
 Democratic-Favoring Districts in 2017 House Plan Versus 1,000 Simulated Plans
 (Measured Using the 2016 Attorney General Election)**



**Appendix A, Figure A3:
Senate Simulation Set 1 (Following Only Non-Partisan Redistricting Criteria):
Democratic-Favoring Districts in 2017 Senate Plan Versus 1,000 Simulated Plans
(Measured Using the 2016 Attorney General Election)**



**Appendix A, Figure A4:
Senate Simulation Set 2 (Following Non-Partisan Redistricting Criteria and Avoiding Incumbent Pairings):
Democratic-Favoring Districts in 2017 Senate Plan Versus 1,000 Simulated Plans
(Measured Using the 2016 Attorney General Election)**

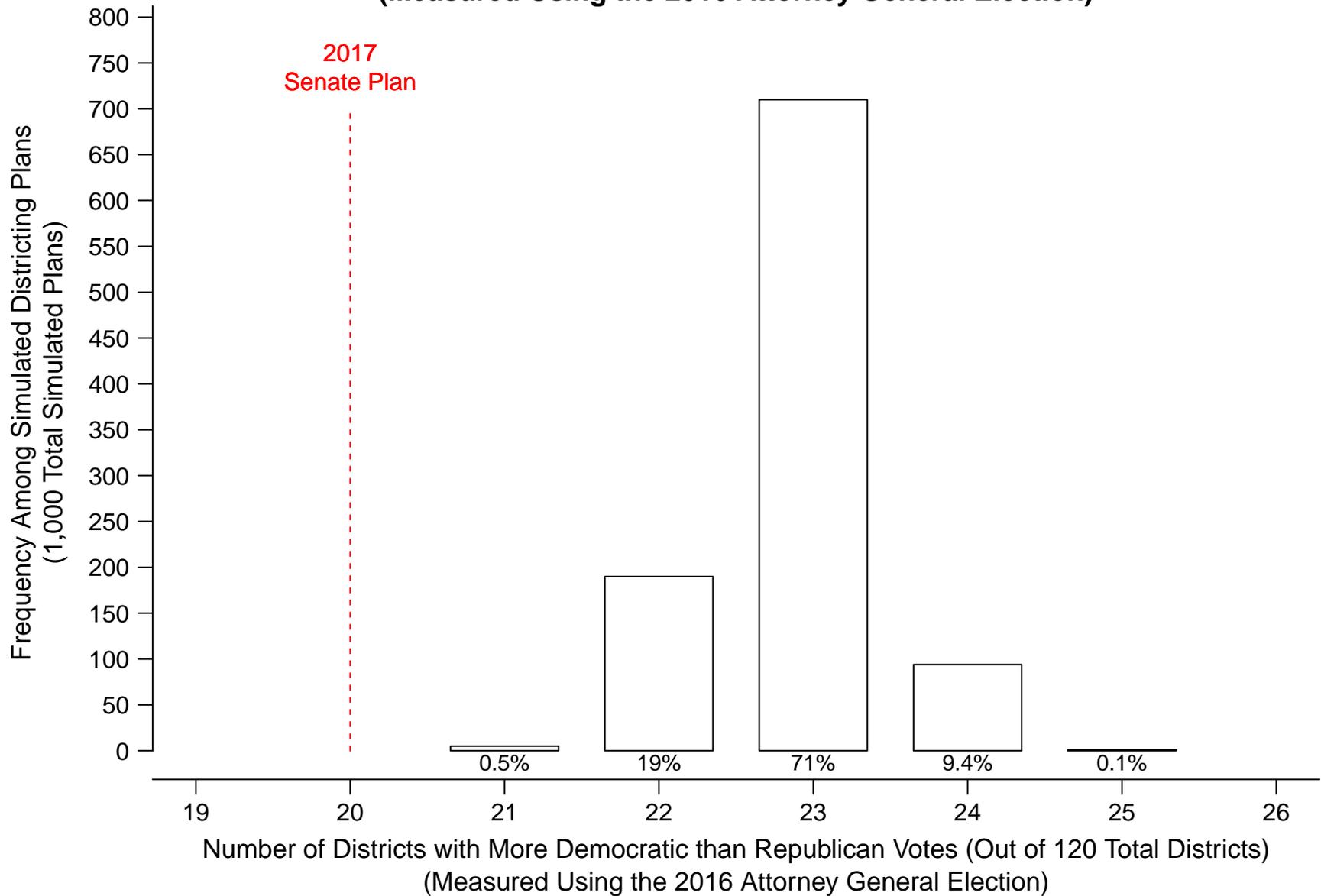


EXHIBIT A

Jowei Chen
Curriculum Vitae

Department of Political Science
University of Michigan
5700 Haven Hall
505 South State Street
Ann Arbor, MI 48109-1045
Phone: 917-861-7712, Email: jowei@umich.edu
Website: <http://www.umich.edu/~jowei>

Academic Positions:

Associate Professor (2015-present), Assistant Professor (2009-2015), Department of Political Science, University of Michigan.
Faculty Associate, Center for Political Studies, University of Michigan, 2009 – Present.
W. Glenn Campbell and Rita Ricardo-Campbell National Fellow, Hoover Institution, Stanford University, 2013.
Principal Investigator and Senior Research Fellow, Center for Governance and Public Policy Research, Willamette University, 2013 – Present.

Education:

Ph.D., Political Science, Stanford University (June 2009)
M.S., Statistics, Stanford University (January 2007)
B.A., Ethics, Politics, and Economics, Yale University (May 2004)

Publications:

Chen, Jowei and Neil Malhotra. 2007. "The Law of k/n: The Effect of Chamber Size on Government Spending in Bicameral Legislatures."
[*American Political Science Review*. 101\(4\): 657-676.](#)

Chen, Jowei, 2010. "The Effect of Electoral Geography on Pork Barreling in Bicameral Legislatures."
[*American Journal of Political Science*. 54\(2\): 301-322.](#)

Chen, Jowei, 2013. "Voter Partisanship and the Effect of Distributive Spending on Political Participation."
[*American Journal of Political Science*. 57\(1\): 200-217.](#)

Chen, Jowei and Jonathan Rodden, 2013. "Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures"
[*Quarterly Journal of Political Science*, 8\(3\): 239-269.](#)

Bradley, Katharine and Jowei Chen, 2014. "Participation Without Representation? Senior Opinion, Legislative Behavior, and Federal Health Reform."

[Journal of Health Politics, Policy and Law. 39\(2\), 263-293.](#)

Chen, Jowei and Tim Johnson, 2015. "Federal Employee Unionization and Presidential Control of the Bureaucracy: Estimating and Explaining Ideological Change in Executive Agencies."

[Journal of Theoretical Politics, Volume 27, No. 1: 151-174.](#)

Bonica, Adam, Jowei Chen, and Tim Johnson, 2015. "Senate Gate-Keeping, Presidential Staffing of 'Inferior Offices' and the Ideological Composition of Appointments to the Public Bureaucracy."

[Quarterly Journal of Political Science. Volume 10, No. 1: 5-40.](#)

Chen, Jowei and Jonathan Rodden, 2015. "Redistricting Simulations and the Detection Cutting through the Thicket: of Partisan Gerrymanders."

[Election Law Journal. Volume 14, Number 4: 331-345.](#)

Chen, Jowei and David Cottrell, 2016. "Evaluating Partisan Gains from Congressional Gerrymandering: Using Computer Simulations to Estimate the Effect of Gerrymandering in the U.S. House."

[Electoral Studies. Volume 44 \(December 2016\): 329-340.](#)

Chen, Jowei, 2017. "Analysis of Computer-Simulated Districting Maps for the Wisconsin State Assembly."

[Forthcoming 2017, Election Law Journal.](#)

Non-Peer-Reviewed Publication:

Chen, Jowei and Tim Johnson. 2017. "Political Ideology in the Bureaucracy."

[Global Encyclopedia of Public Administration, Public Policy, and Governance.](#)

Chen, Jowei. October 4, 2017. Time Magazine Op-Ed.

<http://time.com/4965673/wisconsin-supreme-court-gerrymandering-research/>

Chen, Jowei and Jonathan Rodden. January 2014. New York Times Op-Ed.

<https://www.nytimes.com/2014/01/26/opinion/sunday/its-the-geography-stupid.html>

Research Grants:

Principal Investigator. [National Science Foundation Grant SES-1459459](#), September 2015 – August 2018 (\$165,008). "The Political Control of U.S. Federal Agencies and Bureaucratic Political Behavior."

"Economic Disparity and Federal Investments in Detroit," (with Brian Min) 2011. Graham Institute, University of Michigan (\$30,000).

“The Partisan Effect of OSHA Enforcement on Workplace Injuries,” (with Connor Raso) 2009.
John M. Olin Law and Economics Research Grant (\$4,410).

Invited Talks:

September, 2011. University of Virginia, American Politics Workshop.
October 2011. Massachusetts Institute of Technology, American Politics Conference.
January 2012. University of Chicago, Political Economy/American Politics Seminar.
February 2012. Harvard University, Positive Political Economy Seminar.
September 2012. Emory University, Political Institutions and Methodology Colloquium.
November 2012. University of Wisconsin, Madison, American Politics Workshop.
September 2013. Stanford University, Graduate School of Business, Political Economy Workshop.
February 2014. Princeton University, Center for the Study of Democratic Politics Workshop.
November 2014. Yale University, American Politics and Public Policy Workshop.
December 2014. American Constitution Society for Law & Policy Conference: Building the Evidence to Win Voting Rights Cases.
February 2015. University of Rochester, American Politics Working Group.
March 2015. Harvard University, Voting Rights Act Workshop.
May 2015. Harvard University, Conference on Political Geography.
October 2015. George Washington University School of Law, Conference on Redistricting Reform.
September 2016. Harvard University Center for Governmental and International Studies, Voting Rights Institute Conference.
March 2017. Duke University, Sanford School of Public Policy, Redistricting Reform Conference.
October 2017. Willamette University, Center for Governance and Public Policy Research
October 2017, University of Wisconsin, Madison. Geometry of Redistricting Conference.

Conference Service:

Section Chair, 2017 APSA (Chicago, IL), Political Methodology Section
Discussant, 2014 Political Methodology Conference (University of Georgia)
Section Chair, 2012 MPSA (Chicago, IL), Political Geography Section.
Discussant, 2011 MPSA (Chicago, IL) “Presidential-Congressional Interaction.”
Discussant, 2008 APSA (Boston, MA) “Congressional Appropriations.”
Chair and Discussant, 2008 MPSA (Chicago, IL) “Distributive Politics: Parties and Pork.”

Reviewer Service:

American Journal of Political Science
American Political Science Review
Journal of Politics
Quarterly Journal of Political Science

American Politics Research
Legislative Studies Quarterly
State Politics and Policy Quarterly
Journal of Public Policy
Journal of Empirical Legal Studies
Political Behavior
Political Research Quarterly
Political Analysis
Public Choice
Applied Geography