No. 413PA21 TENTH DISTRICT

SUPREME COURT OF NORTH CAROLINA

****

REBECCA HARPER, et al.,

Plaintiffs,

v.

REPRESENTATIVE DESTIN HALL, in his official capacity as Chair of the House Standing Committee on Redistricting, et al.,

Defendants.

NORTH CAROLINA LEAGUE OF CONSERVATION VOTERS, INC., et al.,

Plaintiffs,

v.

REPRESENTATIVE DESTIN HALL, in his official capacity as Chair of the House Standing Committee on Redistricting, et al.,

Defendants.

EMERGENCY PETITION FOR WRIT OF SUPERSEDEAS AND TEMPORARY STAY OF *HARPER* PLAINTIFFS-APPELLANTS

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TO THE HONORABLE SUPREME COURT OF NORTH CAROLINA:

Harper Plaintiffs respectfully petition this Court to issue a temporary stay and a writ of supersedeas partially staying enforcement of the February 23, 2022 Order of the Wake County Superior Court to the extent that it adopts the remedial State Senate plan enacted as S.B. 744, pending review by this Court. The Court should instead order adoption of the *Harper* Plaintiffs' proposed remedial Senate map, and order the opening of candidate filing tomorrow using *Harper* Plaintiffs' proposed remedial Senate map, and the remedial House and Congressional maps adopted by the trial court.

INTRODUCTION

All four of the Special Masters' quantitative experts found that S.B. 744 is a substantial, pro-Republican partisan gerrymander that denies the Democrats any chance at a majority even when they win well over a majority of the statewide vote. This Court held a week ago that "voters are entitled to have substantially the same opportunity to electing a supermajority or majority of representatives as the voters of the opposing party would be afforded if they comprised [a given] percent of the statewide vote share in that same election." *Harper v. Hall*, No. 413PA21, Opinion ¶ 169 (N.C. Feb. 14, 2022). All four experts concluded that S.B. 744 flunks that partisan symmetry test. Nonetheless, the Special Masters and the trial court approved S.B. 744 because under certain statewide vote fractions, S.B. 744 did not score outside a patently unacceptable range on *one* of the metrics the Court identified, the efficiency gap.

This Court should stay S.B. 744, which "violates the North Carolina Constitution" because "it deprives [the] voter[s] of [their] right to substantially equal voting power on

the basis of partisan affiliation." *Harper v. Hall*, No. 413PA21, Order ¶ 5 (N.C. Feb. 4, 2022). Despite this Court's clear instructions, the General Assembly once again enacted, and the trial court approved, a Senate plan that will predictably secure "partisan advantage incommensurate with a political party's level of statewide voter support." *id.* ¶ 5.

The remedial Senate plan once again clearly violates North Carolina's Free Elections Clause, Equal Protection Clause, Free Speech Clause, and Freedom of Assembly Clause. Analysis from *Harper* Plaintiffs' experts, the Special Masters' assistants, and even Legislative Defendants' own experts uniformly concluded that the enacted remedial Senate plan does not provide anything approaching the partisan symmetry the North Carolina Constitution demands. The asymmetry is stark and profoundly antidemocratic. Democratic voters under this Senate plan will not be able to elect a majority at any realistic vote share. By contrast, Republicans will elect majorities even when winning less than a majority of the vote. And Republicans will frequently win supermajorities at vote shares where Democrats would not even win a majority. These facts are undisputed.

It is imperative that this Court demand full compliance with North Carolina's Declaration of Rights by staying adoption of the Senate map adopted by the trial court today. Because this cycle's districting plans will supply the first benchmark for how much partisan advantage is tolerable under North Carolina law, it is especially important to prevent a gerrymander from taking root before the ink on this Court's landmark Order has dried. *Cf. Clarno v. Fagan*, No. 21CV40180, 2021 WL 5632371, *5 (Or. Nov. 24,

2021) (rejecting partisan gerrymandering claim where enacted map's partisan advantage was comparable to the partisan advantage in previous judicially adopted maps). And the gerrymanders adopted by the superior court today are hardly subtle. Legislative Defendants did not even bother fixing lines in several Senate clusters that were specifically found to be partisan gerrymanders, including in Forsyth County and Buncombe County. If the plan is left in place, *Harper* Plaintiffs will suffer irreparable harm because they will be forced to vote in unconstitutional districts where they do not have a "substantially equal opportunity to translate votes into seats across the plan." Feb. 4 Order ¶ 6. Balancing the equities further supports immediate relief because North Carolina voters deserve to vote in districts that comply with the state's constitution.

Nothing about North Carolina's political geography requires this biased map. The special masters' experts found that *Harper* Plaintiffs' proposed remedial plan is equivalent to S.B. 744 on nonpartisan metrics like compactness and preserving counties, and results in substantially less partisan bias. The Court can accordingly order the election to go forward tomorrow using *Harper* Plaintiffs' proposed Senate map.

For these and the additional reasons explained below, the maps adopted by the superior court are likely to be vacated on appeal and emergency temporary relief is warranted in the interim. Because the issues here are extraordinarily important and time-sensitive, *Harper* Plaintiffs understand this Court's February 4th Order to waive the ordinary requirement that appellants first seek further relief below. Accordingly, *Harper* Plaintiffs now petition this Court directly for a writ of supersedeas and temporary stay.

REASONS WHY THE WRIT OF SUPERSEDEAS SHOULD ISSUE

In determining whether to grant a writ of supersedeas and temporary stay, North Carolina courts apply the familiar test balancing the petitioner's likelihood of success on the merits of the appeal, whether irreparable injury will occur absent a stay, and whether the balance of the equities supports temporary relief. *See Abbott v. Highlands*, 52 N.C. App. 69, 79, 277 S.E.2d 820, 827 (1981); *Home Indem. Co. v. Hoechst Celanese Corp.*, 128 N.C. App. 113, 117-19, 493 S.E.2d 806, 809-11 (1997); *see also N. Iredell Neighbors for Rural Life v. Iredell Cnty.*, 196 N.C. App. 68, 79, 674 S.E.2d 436, 443 (2009). Here, each of these factors favors the grant of a temporary stay and writ of supersedeas.

I. *Harper* Plaintiffs are likely to succeed on the merits in enjoining use of the enacted Senate plan, which systematically prevents Democrats from winning a Senate majority.

This Court is likely to enjoin use of Legislative Defendants' enacted remedial Senate plan, S.B. 744, which the trial court adopted. The evidence is undisputed that the remedial Senate plan prevents Democrats from winning a majority in the Senate under any reasonable election scenario and frequently gives a supermajority to Republicans even at vote shares close to 50-50. All four of the experts the Special Masters hired to evaluate the Senate map found it to be a pro-Republican partisan gerrymander with substantial partisan bias on the metrics this Court identified.

A. The North Carolina Constitution Requires Partisan Symmetry

This Court has held that North Carolina's redistricting plans must give "voters of all political parties substantially equal opportunity to translate votes into seats across the

plan." Feb. 4 Order ¶ 6. In particular, "voters are entitled to have substantially the same opportunity to elect[] a supermajority or majority of representatives as the voters of the opposing party would be afforded if they comprised" a given percentage "of the statewide vote share in that same election." Slip op. ¶ 169. "What matters here, as in the one-person, one-vote context, is that each voter's vote carries roughly the same weight when drawing a redistricting plan that translates votes into seats in the legislative body." *Id.*

A reapportionment plan is thus unconstitutional where the plan "makes it systematically more difficult for a voter to aggregate his or her vote with other likeminded voters." Feb. 4 Order ¶ 5. This violation can be measured "by comparing the number of representatives that a group of voters of one partisan affiliation can plausibly elect with the number of representatives that a group of voters of the same size of another partisan affiliation can plausibly elect." *Id.* Alternatively, a plan's unconstitutionality can be demonstrated "by comparing the relative chances of voters from each party electing a supermajority or majority of representatives under various possible electoral conditions." *Id.* This Court specifically endorsed "mean-median difference analysis, efficiency gap analysis, close-votes, close seats analysis, and partisan symmetry analysis" to assess "whether the mapmaker adhered to traditional neutral districting criteria" and "whether a meaningful partisan skew necessarily results from North Carolina's unique political geography." *Id.* ¶ 6.

B. S.B. 744 undisputedly fails to provide partisan symmetry.

Legislative Defendants' remedial Senate map, which the trial court adopted, flouts this Court's order and opinion by failing to provide voters the substantially equal voting opportunity this Court has required. On this key point, all of the parties' analytical experts, as well as the Special Masters' assistants, were in agreement. No evidence, let alone substantial evidence, supported the trial court's decision to adopt this map.

1. The Special Masters' assistants uniformly found that S.B. 744 does not provide partisan symmetry.

The Special Masters retained assistants to provide quantitative analysis of the proposed remedial plans. *See* App. 25 (Special Masters' Report at 1). All four of these assistants concluded that S.B. 744 fails partisan symmetry. In particular:

Dr. Eric McGhee concluded that S.B. 744, although better than the 2021 plan, flunked partisan symmetry: "in a tied election Republicans would still hold 27 or 28 seats," while "Democrats would need to win as much as 53 percent of the vote to claim 25 seats." App. 38 (McGhee Senate Report at 6). Dr. McGhee also found that S.B. 744 had a mean-median differential of 2.2%, App. 36 (Report at 4), which exceeds both the 0.8% differential he found for *Harper* Plaintiffs' plan and the 1% mean-median threshold identified by this Court as presumptively constitutional, *see* Slip Op. ¶ 166.

Dr. Tyler Jarvis concluded that Legislative Defendants' proposed Senate remedial plan "is often a significant outlier in favor of the Republicans" in comparison to Dr. Mattingly's non-partisan ensemble. App. 53 (Jarvis Report at 15). By contrast, *Harper* Plaintiffs' proposed Senate plan is "mostly typical of the ensemble." *Id.* Dr. Jarvis also

found "strong evidence of partisan gerrymandering in the LD plan." App. 56 (Jarvis Report at 18).

Dr. Jarvis also found that the average mean-median differential for the Legislative Defendants' plan was 1.4% in favor of the Republicans, with a score as high as 3% in one election. App. 61 (Report at 23). By contrast, *Harper* Plaintiffs' plan had an average mean-median score of 0. *Id.* He found that the average "partisan bias" score for the Legislative Defendants' plan was 4% in favor of Republicans, compared to 0.5% in favor of Republicans for Harper Plaintiffs' plan. *Id.* The average efficiency gap score was 4% for Legislative Defendants' plan, and 1.1% for Harper Plaintiffs, both in favor of Republicans. App. 62 (Report at 24).

Dr. Sam Wang agreed that S.B. 744 systematically favors Republicans, finding that across elections the "seat partisan asymmetry is a 2.1-seat difference in favor of Republicans." App. 84 (Report at 11). And "[a]ll of the five other metrics"—mean-median difference, partisan bias, lopsided wins difference, declination, and efficiency gap—"also favor Republicans." *Id.*; *see* App. 85. While Dr. Wang concluded that S.B. 744's mean-median differential was less than 1%, he did so using a single election composite where the Republicans win approximately 51% of the two-party vote share. App. 77 (Report at 4).[1]

[1] Dr. Wang also appears to have made typographical or computational errors in assessing *Harper* Plaintiffs' remedial plans. For example, page 12 of Dr. Wang's report states that *Harper* Plaintiffs' plan produces a 11.1 degree declination angle that favors Democrats, while page 14 states that the angle favors Republicans. He inconsistently reports that *Harper* Plaintiffs' plan gives the Republicans a .8 seat advantage in a 50-50 election, but

Dr. Bernard Grofman likewise found "a substantial pro-Republican bias [in the Senate map] in terms of the likelihood that a majority of the voters will be able to win a majority of the seats." App. 112. He concluded that "only a win by considerably more than 50% of the statewide vote can yield the Democrats a majority of the seats." *Id.* "In a state that is in recent history one that is nearly evenly divided," S.B. 744 "creates a distribution of voting strength across districts that is very lopsidedly Republican." *Id.* The map creates "24 Republican leaning districts that, based on averaged recent data will, barring a political tsunami, elect Republicans; 17 Democratic leaning districts that will, barring a political tsunami, elect Democrats; and [9] competitive districts. Democrats would have to win nine of the nine competitive seats to win a majority in the Senate." *Id.* "Because they all point in the same direction, the political effects statistical indicators of partisan gerrymandering argue for the conclusion that this NC Senate map should be viewed as a pro-Republican gerrymander." App. 113. And while Dr. Grofman concluded that S.B. 744's mean-median differential was less than 1%, he (similar to Dr. Wang) calculated the mean-median gap based on only a single averaged election where the Republicans win 50.8% of the two-party vote share. *See* App. 109, 112–13.

The Special Masters' report, which formed the basis for the trial court's opinion, largely ignored these uniform findings that S.B. 744 lacks partisan symmetry. The report instead focused only on two metrics, noting that (1) all of the advisors had found that the

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gives Democrats a 1.3 average seat advantage. In fact, as all the other expert reports confirm, *Harper* Plaintiffs' plan is largely symmetrical but the asymmetries favor Republicans, not Democrats.

efficiency gap of the proposed Senate plan was less than 7% and that (2) "[t]he majority of the advisors and experts found the mean-median difference of the proposed remedial Senate plan to be less than 1%." App. 27 (Special Masters' Report at 3). The second statement is simply incorrect; only two of the Special Masters' assistants determined that the mean-median differential was less than 1% and, as explained above, both used a methodology that did not account for variation in the mean-median differential across different elections. Meanwhile, two of the assistants found that the mean-median differential exceeded 1%—a conclusion consistent with that of *Harper* Plaintiffs' experts and the *NCLCV* Plaintiffs' expert.

And more broadly, the Special Masters (and in turn the trial court) failed to even acknowledge the uniform findings of the assistants regarding the significant partisan skew of this map on other key metrics of fairness. Dr. McGhee, for example, concluded that "in a tied election Republicans would still hold 27 or 28 seats," while "Democrats would need to win as much as 53 percent of the vote to claim 25 seats." App. 38 (McGhee Senate Report at 6). That outcome is not substantially equal.

2. *Harper* Plaintiffs' experts find significant, asymmetric treatment of Democratic and Republican voters.

Harper Plaintiffs' experts agreed with these uniform findings from the Special Masters' assistants. To implement this Court's directive that voters have substantially the same opportunity to elect a majority or supermajority at a given vote share, *Harper* Plaintiffs' testifying expert Dr. Jonathan Mattingly and his colleague Dr. Gregory Herschlag (the Phillip Griffiths Assistant Research Professor of Mathematics at Duke

University) measured the partisan symmetry of S.B. 744 and of *Harper* Plaintiffs' proposed remedial plan using a metric that uses *symmetric, reciprocal pairs* of Democratic vote shares across a range of recent, statewide elections and calculates how those two symmetric vote shares would translate into seats elected for that party in Senate. *See* App. 132–33 (Mattingly-Herschlag Remedial Report at 2-3).

To take an example: Dr. Mattingly and Dr. Herschlag began with the results of the 2016 gubernatorial election and applied a "uniform swing" to the election results to reflect a 48% Democratic statewide vote share for that election. They calculated how many Republican Senators would be elected under S.B. 744 with that 48% Democratic vote share. They then applied a uniform swing to that election so that it reflected the corresponding, reciprocal Democratic vote share—*i.e.*, 52%. They then computed the number of *Democratic* Senators that would be elected with that 52% Democratic vote share. They then calculated the *absolute difference* between the number of Republican Senators elected with 48% Democratic vote share and the number of Democratic Senators elected with a 52% Democratic vote share. Thus, if 27 Republicans were elected with 48% Democratic vote share, and 25 Democrats were elected with 52% vote share, the absolute difference would be *2 seats*. (Because the figure is absolute, the value is always positive. It does not reflect which party benefits from the asymmetry; it captures only the *degree* of asymmetry.) Dr. Mattingly and Dr. Herschlag repeated that process using several sets of reciprocal vote fractions—45% and 55%, 46% and 54%, 47% and 53%, and 49% and 51%. They did this for each of the 16 statewide elections listed above, and then calculated an *average* of the absolute difference between the number of

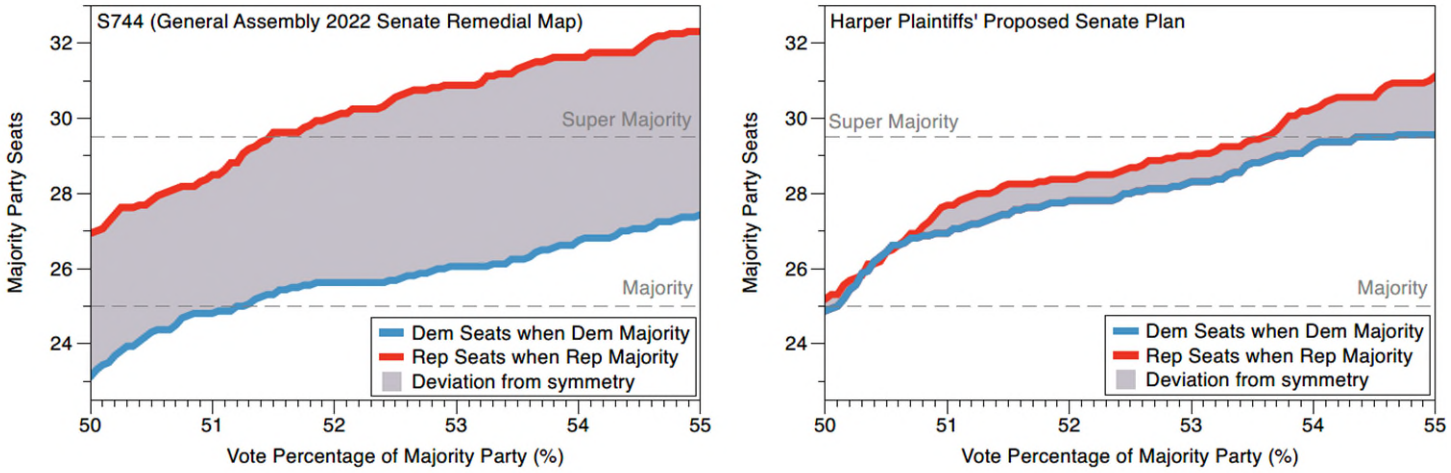
Republican seats elected (under the lower Democratic vote share) and the number of Democratic seats elected (under the higher Democratic vote share). *See* App. 132–33 (Mattingly-Herschlag Remedial Report at 2-3).

The metric thus captures the *average, absolute deviation*, across elections and across vote shares, between the number of seats that the two parties are expected to elect at the same given vote share. *Lower* numbers reflect *greater* partisan symmetry, and in particular, reflect a more "equal opportunity to electing a supermajority or majority of representatives as the voters of the opposing party would be afforded if they comprised" a given percentage "of the statewide vote share in that same election." *Harper* slip op. ¶ 169. Legislative Defendants' expert Dr. Michael Barber endorsed this general approach to evaluating partisan symmetry: "The basic idea is to look at the vote share in each district and increase/decrease the vote share in each district by a uniform amount across a range of outcomes," and "as Democrats gain more votes statewide, the translation of those votes to seats should be similar to when Republicans gain an equally large share of the votes." App. 184–85 (Barber Remedial Report at 17-18).

Under this measure of partisan symmetry, the deviation in Legislative Defendants' plan is an enormous **4.0125** seats. This means that in any given election, across a range of vote shares between 50 and 55%, Republicans would be expected to elect ***four more Senators*** than Democrats would elect at the same vote share. This is *an extreme asymmetry*. *Harper* Plaintiffs' proposed Senate plan produced an average deviation in seats won at a given party vote share of only **1.04375 seats**. And nothing in North Carolina's political geography requires Legislative Defendants' four-Senator differential.

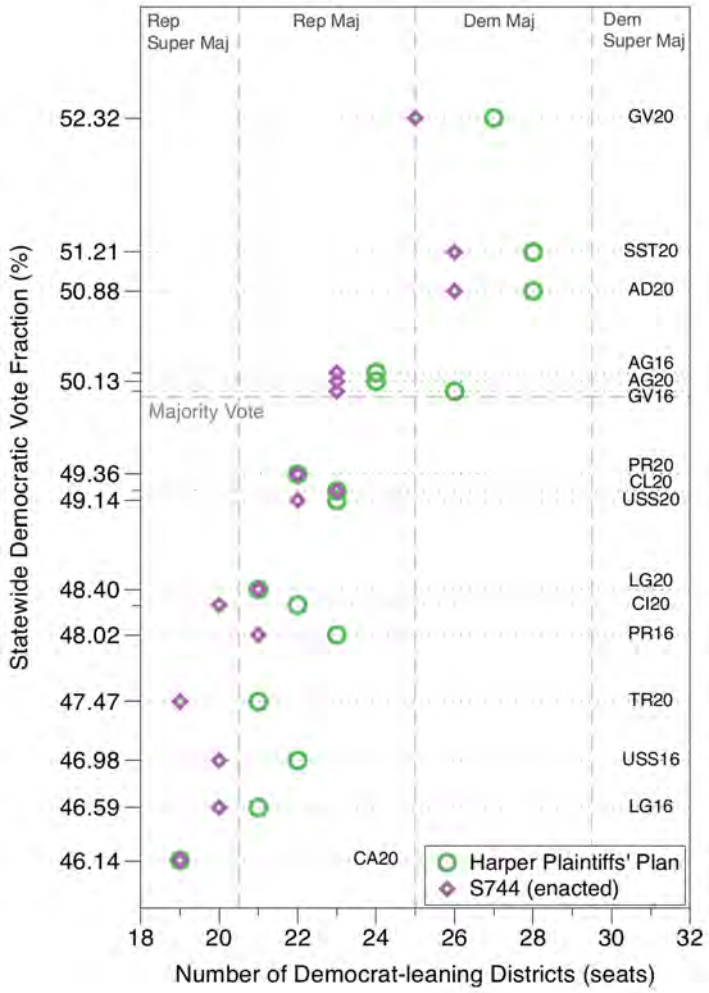
If Legislative Defendants had selected *even a single random plan* from Dr. Mattingly's ensemble of 80,000 computer-generated maps—which were not drawn to prioritize partisan symmetry in any way—that plan would have had better partisan symmetry than S.B. 744 with **99.6%** probability. App. 136 (Mattingly-Herschlag Rep. 6).

This asymmetry is significant across election outcomes, as shown in Figure 4 from the Mattingly-Herschlag report, which shows the number of seats for each party that are expected at the same vote share in S.B. 744 and in *Harper* Plaintiffs' proposed Senate plan, using uniform swing analysis. Once again, the contrast is stark; it shows that S.B. 744 isn't even trying to ensure that the parties have a substantially equal opportunity to translate votes into seats:



Seat counts under historical elections confirm S.B. 744's extreme asymmetry. Figure 3 from the Mattingly-Herschlag report shows that Democrats win a minority of seats in *half* the elections where they won a majority of the vote. Yet again, this antidemocratic result is not symmetrical: there isn't a single election where the Republicans win a majority of votes but a minority of seats. The asymmetry also protects

Republican supermajorities: When Democrats win 51.21% of the vote under the 2020 Secretary of State election, they barely win a majority of seats. Meanwhile, when Republicans get a similar vote share under the 2020 Commissioner of Insurance election, they win a safe supermajority:



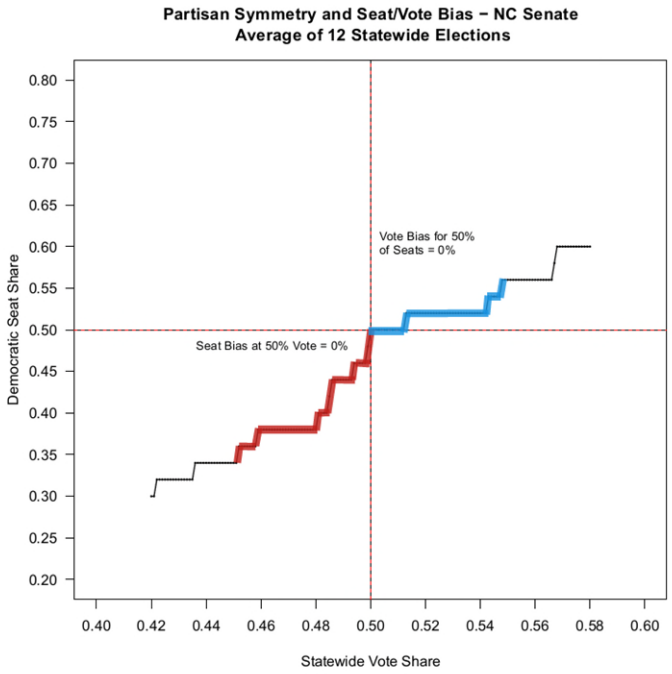
Finally, Drs. Mattingly and Herschlag concluded that Legislative Defendants' proposed Senate plan also fails the 1% mean-median threshold identified by this Court as presumptively constitutional, with a mean-median difference of 1.304%. App. 136 (Mattingly-Herschlag Remedial Rep. 6). By comparison, *Harper* Plaintiffs' proposed

Senate plan has a mean-median difference of 0.228% and an efficiency gap of less than 2%. *Id.*

3. Legislative Defendants' expert agrees that S.B. 744 treats voters asymmetrically.

Finally, even the analysis of Legislative Defendants' expert, Dr. Michael Barber, confirms the lack of partisan symmetry in their Senate plan. As shown in Dr. Barber's Figure 9(b) from his remedial-phase report, highlighted in red and blue below, Democrats need dramatic increases in vote share to produce additional seats and have effectively no chance at winning a supermajority even at unprecedented vote shares. App. 206. For example, Democrats must ascend from 50% vote share to nearly 55% vote share before gaining a 28th seat, and are still 2 seats short of a supermajority. If Republicans experience that same 5-point increase from 50% to 55%, their seat count jumps to 33 seats—well over a supermajority.

(b) 2022 Remedial plan



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In short, all of the quantitative evidence presented to the trial court showed the same thing: The enacted remedial Senate plan does not give voters "substantially the same opportunity to elect[] a supermajority or majority of representatives as the voters of the opposing party would be afforded if they comprised" a given percentage "of the statewide vote share in that same election." Slip op. ¶ 169. The plan does not comply with this Court's ruling, and the Court is likely to hold that the trial court clearly erred by adopting it.

II. The trial court's Order will cause irreparable injury and is contrary to the balance of the equities and the public interest.

As explained above, the superior court's order today adopts an unconstitutional plan wherein "some peoples' votes have more power than others." *Harper*, slip. op. ¶ 5.

If this map is used in the upcoming elections, Plaintiffs will be forced to vote in 2022 in unlawful districts that violate "the individual rights of voters to cast votes that matter equally, as guaranteed by our constitution in article I, sections 10, 12, 14, and 19." Slip op. ¶ 9; *see Northampton Cnty. Drainage Dist. No. One v. Bailey*, 326 N.C. 742, 747 (1990) (The "right to vote on equal terms is a fundamental right.").

The "fundamental right[s]" at issue "encompass[] the opportunity to aggregate one's vote with likeminded citizens to elect a governing majority of elected officials who reflect those citizens' views." Slip op. ¶ 179. And when, as here, "on the basis of partisanship the General Assembly enacts a districting plan that diminishes or dilutes a voter's opportunity to aggregate with likeminded voters to elect a governing majority . . . the General Assembly infringes upon that voter's fundamental right to vote." Slip op. ¶ 179. The loss of these constitutional rights irreparably injures Plaintiffs and all North Carolinians. *See Elrod v. Burns*, 427 U.S. 347, 373 (1976) ("[A]n infringement of voting and associational rights . . . cannot be alleviated after the election.); *Council of Alternative Political Parties v. Hooks*, 121 F.3d 876, 883 (3d Cir. 1997); *see also League of Women Voters of N.C. v. North Carolina*, 769 F.3d 224, 247 (4th Cir. 2014) (recognizing courts routinely deem restrictions on fundamental rights to cause irreparable injury).

This Court must therefore once again exercise its "most fundamental [] sacred dut[y]" to "protect the constitutional rights of the people of North Carolina from overreach by the General Assembly." Slip op. ¶ 7. Just as with the 2016 congressional plan and the 2021 redistricting plans, the superior court's ordered plans will "prevent

elections from reflecting the will of the people impartially" and "dilut[e] voting power on the basis of partisan affiliation." Slip Op. ¶ 141. Only a fair, nonpartisan remedial plan can ensure that the districts where Plaintiffs live and vote are not the product of illegal discrimination by their government.

This case is about the rights of all North Carolina citizens to vote in lawful districts that will reveal, fairly and truthfully, the will of the people. Absent this Court's intervention, Plaintiffs and their fellow citizens will be forced to cast their ballots in invalid, unconstitutional Senate districts in 2022. It would be inequitable in the extreme to force them do so.

MOTION FOR TEMPORARY STAY

Pursuant to Rules 8 and 23(e) of the North Carolina Rules of Appellate Procedure and this Court's February 4, 2022 Order, *Harper* Plaintiffs respectfully apply to this Court for an order temporarily staying enforcement of S.B. 744 until determination of this Court as to whether it shall issue its writ of supersedeas. *Harper* Plaintiffs incorporate and rely on the arguments presented in the foregoing Petition for Writ of Supersedeas in support of this Motion for Temporary Stay.

CONCLUSION

Wherefore, *Harper* Plaintiffs respectfully pray that this Court issue a writ of supersedeas to the superior court, staying enforcement of the Order entered today as to only the adoption of a remedial Senate map pending issuance of the mandate to this Court following its review and determination upon the appeal which will be timely perfected; and that *Harper* Plaintiffs shall have such other relief as to the Court may seem proper.

Harper Plaintiffs also request that this Court temporarily stay enforcement of the Order entered below as to the adoption of a remedial Senate map until such time as this Court rules on the foregoing Petition for Writ of Supersedeas.

Respectfully submitted, this 23rd day of February, 2022.

PATTERSON HARKAVY LLP

Electronically submitted
Narendra K. Ghosh, NC Bar No. 37649
100 Europa Dr., Suite 420
Chapel Hill, NC 27517
(919) 942-5200
nghosh@pathlaw.com

N.C. R. App. P. 33(b) Certification:
I certify that all of the attorneys listed have authorized me to list their names on this document as if they had personally signed it.

Burton Craige, NC Bar No. 9180
Paul E. Smith, NC Bar No. 45014
PATTERSON HARKAVY LLP
100 Europa Dr., Suite 420
Chapel Hill, NC 27517
(919) 942-5200
bcraige@pathlaw.com
psmith@pathlaw.com

ELIAS LAW GROUP LLP

Abha Khanna*
1700 Seventh Avenue, Suite 2100
Seattle, Washington 98101
Phone: (206) 656-0177
Facsimile: (206) 656-0180
AKhanna@elias.law

Lalitha D. Madduri*
Jacob D. Shelly*
Graham W. White*
10 G Street NE, Suite 600
Washington, D.C. 20002
Phone: (202) 968-4490
Facsimile: (202) 968-4498
LMadduri@elias.law
JShelly@elias.law
GWhite@elias.law

ARNOLD AND PORTER KAYE SCHOLER LLP

Elisabeth S. Theodore*
R. Stanton Jones*
Samuel F. Callahan*
601 Massachusetts Avenue NW
Washington, DC 20001-3743
(202) 954-5000
elisabeth.theodore@arnoldporter.com

**Admitted pro hac vice*

Counsel for Harper Plaintiffs

VERIFICATION

I, Narendra K. Ghosh, after being duly sworn, state:

I am counsel for the *Harper* Plaintiffs. The material allegations of the petition are true to my personal knowledge, except for those matters stated upon information and belief and, as to those matters, I believe them to be true.

Pursuant to Appellant Rule 23, I also hereby certify that the documents attached to this Petition for Writ of Supersedeas and Motion for Temporary Stay are true and correct copies of the pleadings and other documents from the file in Wake County Superior Court.

Narendra K. Ghosh

Sworn to and subscribed before me,
this the 23rd day of February, 2022.

Notary Public Beverly L. Olson

My commission expires: May 12, 2024

CERTIFICATE OF COMPLIANCE

Pursuant to Rule 28(j) of the North Carolina Rules of Appellate procedure, counsel for Plaintiff certifies that the foregoing brief, which was prepared using a 13-point proportionally spaced font with serifs.

Electronically submitted
Narendra K. Ghosh

CERTIFICATE OF SERVICE

The undersigned hereby certifies that on the 23rd day of February, 2022, a copy of the foregoing Petition was electronically filed and served by electronic mail on counsel of record for Defendants-Appellees as follows:

Amar Majmundar
Stephanie A. Brennan
Terence Steed
NC Department of Justice
P.O. Box 629
Raleigh, NC 27602
amajmundar@ncdoj.gov
sbrennan@ncdoj.gov
tsteed@ncdoj.gov

Counsel for the State Defendants

Allison J. Riggs
Hilary H. Klein
Mitchell Brown
Katelin Kaiser
Jeffrey Loperfido
Southern Coalition for Social Justice
1415 W. Highway 54, Suite 101
Durham, NC 27707
allison@southerncoalition.org
hilaryhklein@scsj.org
mitchellbrown@scsj.org
katelin@scsj.org
jeffloperfido@scsj.org

J. Tom Boer
Olivia T. Molodanof
Hogan Lovells US LLP
3 Embarcadero Center, Suite 1500
San Francisco, CA 94111
tom.boer@hoganlovells.com
oliviamolodanof@hoganlovells.com

Counsel for Plaintiff Common Cause

Phillip J. Strach
Alyssa Riggins
John E. Branch, III
Thomas A. Farr
Nelson Mullins Riley & Scarborough LLP
4140 Parklake Ave., Suite 200
Raleigh, NC 27612
phil.strach@nelsonmullins.com
alyssa.riggins@nelsonmullins.com
john.branch@nelsonmullins.com
tom.farr@nelsonmullins.com

Mark E. Braden
Katherine McKnight
Baker Hostetler LLP
1050 Connecticut Avenue NW,
Suite 1100
Washington, DC 20036
mbraden@bakerlaw.com
kmcknight@bakerlaw.com

Counsel for the Legislative Defendants

Stephen D. Feldman
Adam K. Doerr
Erik R. Zimmerman
Robinson, Bradshaw & Hinson PA
434 Fayetteville Street, Suite 1600
Raleigh, NC 27601
sfeldman@robinsonbradshaw.com
adoerr@robinsonbradshaw.com
ezimmerman@robinsonbradshaw.com

Sam Hirsch
Jessica Ring Amunson
Zachary C. Schuaf
Karthik P. Reddy
Urja Mittal
JENNER & BLOCK LLP
1099 New York Avenue, NW, Suite 900
Washington, D.C. 20001
shirsch@jenner.com
jamunson@jenner.com
zschauf@jenner.com
kreddy@jenner.com
umittal@jenner.com

Counsel for NCLCV Plaintiffs

Electronically submitted
Narendra K. Ghosh

APPENDIX

Contents of Appendix

STATE OF NORTH CAROLINA

COUNTY OF WAKE

IN THE GENERAL COURT OF JUSTICE
SUPERIOR COURT DIVISION
FILE NO. 21 CVS 015426

NORTH CAROLINA LEAGUE, OF CONSERVATION VOTERS, INC., *et al.*,
Plaintiffs,

COMMON CAUSE,
Plaintiff-Intervenor,

v.

REPRESENTATIVE DESTIN HALL, in his official capacity as Chair of the House Standing Committee on Redistricting, *et al.*,
Defendants.

STATE OF NORTH CAROLINA

COUNTY OF WAKE

IN THE GENERAL COURT OF JUSTICE
SUPERIOR COURT DIVISION
FILE NO. 21 CVS 500085

REBECCA HARPER, *et al.*,
Plaintiffs,

v.

REPRESENTATIVE DESTIN HALL, in his official capacity as Chair of the House Standing Committee on Redistricting, *et al.*,
Defendants.

ORDER ON REMEDIAL PLANS

THIS MATTER comes before the undersigned three-judge panel pursuant to the February 4, 2022, Order of the Supreme Court of North Carolina ("Supreme Court Remedial Order) for review of Remedial Redistricting Plans to apportion the state legislative and congressional districts within North Carolina (hereinafter collectively referred to as the "Remedial Plans") enacted by the North Carolina General Assembly on February 17, 2022. 2022 N.C. Sess. Laws. 2 (also known as Senate Bill 744 and hereafter referred to as "Remedial Senate Plan"); 2022 N.C. Sess. Laws. 4 (also known as House Bill 980 and hereafter referred to as "Remedial House Plan"); 2022 N.C. Sess. Laws. 3 (also known as Senate Bill 745 and hereafter referred to as "Remedial Congressional Plan").

The Remedial Plans were enacted following entry of the Supreme Court Remedial Order. This Court entered a Judgment on January 11, 2022, wherein the Court upheld the constitutionality of the 2021 Enacted State Legislative and Congressional redistricting plans (hereinafter "Enacted Plans"). Thereafter, Harper Plaintiffs, North Carolina League of Conservation Voters Plaintiffs, and Plaintiff-Intervenor Common Cause (hereinafter collectively referred to as "Plaintiffs") appealed this Court's Judgment directly to the Supreme Court of North Carolina. On February 4, 2022, the Supreme Court of North Carolina entered its Remedial Order, with opinion to follow, adopting in full this Court's findings of fact in the January 11, 2022, Judgment; however, the Supreme Court concluded that the Enacted Plans are unconstitutional under N.C. Const., art. I, §§ 10, 12, 14, and 19 and remanded the action to this Court for remedial proceedings. On February 14, 2022, the Supreme

Court filed its full opinion in this action. *Harper v. Hall*, 2022-NCSC-17 (Feb. 14, 2022).

Pursuant to the Supreme Court Remedial Order and full opinion, and after reviewing all remedial and alternative plans submitted to this Court, as well as additional documents, materials, and information pertaining to the submitted plans, including the report of this Court's appointed Special Masters and comments received from the parties, this Court sets out the following:

FINDINGS OF FACT

I. Summary of Requirements for Remedial Process

1. The Supreme Court's Order required the submission to this Court of remedial state legislative and congressional redistricting plans that "satisfy all provisions of the North Carolina Constitution"; both the General Assembly, and any parties to this action who chose to submit proposed remedial plans for this Court's consideration, were required to submit such plans, and additional information, on or before February 18, 2022, at 5:00 p.m.

2. The Supreme Court's Order also provided for a comment period in which parties to these consolidated cases were permitted to file and submit to this Court comments on any plans submitted for this Court's consideration by February 21, 2022 at 5:00 p.m.

3. The Supreme Court's Order also mandated that this Court must approve or adopt constitutionally compliant remedial plans by noon on February 23, 2022.

4. This Court subsequently entered an order on February 8, 2022, providing initial guidance on the remedial phase of the litigation before this Court,

requiring written submissions containing the information the Supreme Court set forth in its Order pertaining to redistricting plans in general and the ordered Remedial Plans specifically. The written submissions were required to provide an explanation of the data and other considerations the mapmaker relied upon to create any submitted proposed remedial plan and to determine that the proposed remedial plan was constitutional—*i.e.*, compliant with the Supreme Court Remedial Order. The full opinion of the Supreme Court, *Harper v. Hall*, 2022-NCSC-17, thereafter provided further guidance for the Remedial Plans.

5. On February 16, 2022, this Court entered an Order appointing three former jurists of our State appellate and trial courts—Robert F. Orr, Robert H. Edmunds, Jr., and Thomas W. Ross—to serve as Special Masters for the purposes of: 1) assisting this Court in reviewing any Proposed Remedial Plans enacted and submitted by the General Assembly or otherwise submitted to the Court by a party in these consolidated cases; and, 2) assisting this Court in fulfilling the Supreme Court's directive to this Court to develop remedial plans based upon the findings in this Court's January 11, 2022, Judgment should the General Assembly fail to enact and submit Proposed Remedial Plans compliant with the Supreme Court's Order within the time allowed. This Appointment Order also required the submission of additional information, data, and materials for review by the Court, the parties, and the Special Masters.

6. The Appointment Order further provided that the Special Masters were authorized to hire assistants and advisors reasonably necessary to complete their

work. Pursuant to this authorization, the Special Masters hired the following advisors to assist in evaluating the Remedial Plans:

a. Bernard Grofman: PhD in political science from the University of Chicago, and currently the Jack W. Peltason Endowed Chair and Distinguished Professor at the University of California, Irvine, School of Social Sciences;

b. Tyler Jarvis: PhD in mathematics from Princeton University, and currently a Professor at Brigham Young University's College of Physical and Mathematical Sciences;

c. Eric McGhee: PhD in political science from the University of California, Berkeley, and currently a Senior Fellow at Public Policy Institute of California, a non-partisan, non-profit think tank; and,

d. Samuel Wang: PhD in Neurosciences from Stanford University, and currently a Professor of neuroscience at Princeton University and Director of the Electoral Innovation Lab.

7. The Court finds that these advisors were reasonably necessary to facilitate the work of the Special Masters to provide this Court with an analysis of the Remedial Plans.[1]

II. The General Assembly's Remedial Plans as a Whole

8. Pursuant to the Supreme Court's directive, the General Assembly enacted Remedial Plans and, through the Legislative Defendants, timely submitted the Remedial Plans to this Court on February 18, 2022.

[1] On February 20, 2022, counsel for Harper Plaintiffs submitted a notice of communications wherein the Court was informed that Dr. Wang and Dr. Jarvis had contacted some of Harper Plaintiffs' retained experts by email regarding their algorithms and analysis models. Legislative Defendants subsequently filed a motion to disqualify Dr. Wang and Dr. Jarvis from assisting the Special Masters. The Special Masters have provided additional review of the issues presented in this motion, as noted in the Report attached to this Order, and the Court will address the Motion in a separate order that will be filed contemporaneously herewith.

A. Participants in the General Assembly's Drawing of Remedial Plans

9. The House participants involved in the drawing of the Remedial Plans consisted of twenty-one Republican members and one Democratic member, with five Republican staff members and two Democratic staff members.

10. The Senate participants involved in the drawing of the Remedial Plans consisted of four Republican members and five Democratic members, with four Republican staff members and one Democratic staff member.

11. The General Assembly members were also supported by fifteen Legislative Analysis and Bill Drafting Division staff members, as well as four Information Systems Division staff members.

12. Legislative Defendants, through counsel, also relied for limited purposes on their experts and non-testifying experts in this case, including Clark Bensen and Sean Trende for statistical analysis, Dr. Jeffrey Lewis to conduct a Racially Polarized Voting Analysis for both the 2021 and the 2022 districts, and Dr. Michael Barber for statistical analyses of the Remedial Plans and other BVAP-related information.

B. The General Assembly's Remedial Criteria for Drawing the Remedial Plans

13. The General Assembly's Remedial Criteria governing the remedial map drawing process were those neutral and traditional redistricting criteria adopted by the Joint Redistricting Committees on August 12, 2021, (received into evidence at trial as exhibit LDTX15) unless the criteria conflicted with the Supreme Court Remedial Order and full opinion.

14. Although expressly forbidden by the previously-used August 2021 Criteria, the General Assembly as part of its Remedial Criteria intentionally used partisan election data as directed by the Supreme Court's Remedial Order. The General Assembly did so by loading such data into Maptitude, the map drawing software utilized by the General Assembly in creating districting plans. The elections used by the General Assembly to evaluate the projected partisan effects of district lines were as follows: Lt. Gov 2016, President 2016, Commissioner of Agriculture 2020, Treasurer 2020, Lt. Gov. 2020, US Senate 2020, Commissioner of Labor 2020, President 2020, Attorney General 2020, Auditor 2020, Secretary of State 2020, and Governor 2020.

15. The Court finds that the General Assembly's use of partisan data in this manner comported with the Supreme Court Remedial Order.

C. The General Assembly's Racially Polarized Voting Analysis

16. Paragraph 8 of the Supreme Court Remedial Order required the General Assembly to "assess whether, using current election and population data, racially polarized voting is legally sufficient in any area of the state such that Section 2 of the Voting Rights Act requires the drawing of a district to avoid diluting the voting strength of African-American voters."

17. The General Assembly conducted an abbreviated racially polarized voting ("RPV") analysis to determine whether racially polarized voting is legally sufficient in any area of the state such that Section 2 of the Voting Rights Act *requires* the drawing of a district to avoid diluting the voting strength of African American voters during the remedial process. Legislative Defendants' expert Dr. Jeffery B.

Lewis ran an analysis and concluded that all three Remedial Plans provide African Americans with proportional opportunity to elect their candidates of choice.

18. The Court finds that the General Assembly satisfied the directive in the Supreme Court Remedial Order to determine whether the drawing of a district in an area of the state is required to comply with Section 2 of the Voting Rights Act.

D. Plaintiffs' Objections and Comments to the Plans

19. Pursuant to the Supreme Court's directive, Plaintiffs timely submitted comments on and objections to the Remedial Plans on February 21, 2022.

20. NCLCV Plaintiffs object to the Remedial Senate and Congressional Plans. NCLCV Plaintiffs do not specifically object to the Remedial House Plan but instead request the Court conduct its own analysis of the Remedial House Plan.

21. Harper Plaintiffs object to the Remedial Congressional Plan and Remedial Senate Plan. Harper Plaintiffs do not object to the Remedial House Plan.

22. Plaintiff Common Cause objects to all three Remedial Plans in general and specifically contends the Remedial Senate and House Plans must be redrawn for Senate District 4 and House District 10.

E. Report of Special Masters

23. Pursuant to this Court's Appointment Order, the Special Masters prepared a Report containing their analysis and submitted that Report to this Court for its consideration. The Report is attached to this Order as an exhibit and has been filed with the Court.

24. The Special Masters, and their advisors, conducted an analysis of the Remedial Plans using a variety of metrics to determine whether the submitted maps

meet the requirements of the North Carolina Constitution as set out by the Supreme Court of North Carolina in its Remedial Order and full opinion.

25. The Special Masters' findings demonstrate that the Remedial House and Senate Plans meet the requirements of the Supreme Court's Remedial Order and full opinion.

26. The Special Masters' findings demonstrate that the Remedial Congressional Plan does not meet the requirements of the Supreme Court's Remedial Order and full opinion.

27. This Court adopts in full the findings of the Special Masters and sets out additional specific findings on the Remedial Plans' compliance with the Supreme Court Remedial Order below.

III. Remedial Congressional Plan

A. The General Assembly's Starting Point and Subsequently Proposed Amendments

28. In determining the base map for the Congressional Districts in the Remedial Congressional Plan that was eventually enacted, the Senate started from scratch.

29. There was a House Draft of a remedial congressional plan that was never voted on and therefore never considered by a committee or the full General Assembly.

30. Senator Clark offered one amendment to the Remedial Congressional Plan, a statewide plan, that was tabled.

31. The Remedial Congressional Plans passed the Senate by a vote of 25-19. The "aye" votes in the Senate were solely by members of the Republican party, while the "no" votes in the Senate were solely by members of the Democratic Party. The Remedial Congressional Plan passed the House by voice vote along party lines.

B. Analysis of Partisanship Reflected in the Remedial Congressional Plan

32. The Remedial Congressional Plan reflects key differences from the 2021 Enacted Congressional Plan in the projected partisan makeup of certain districts.

a. Four congressional districts are some of the most politically competitive in the country (*i.e.*, presidential election differences of less than 5%): District 6, District 7, District 13, and District 14.

b. Wake and Mecklenburg Counties are only split across two districts unlike in the 2021 Enacted Congressional Plan when each county was split across three districts.

33. The Supreme Court Remedial Order stated that a combination of different methods could be used to evaluate the partisan fairness of a districting plan; of those methods, the General Assembly used the "mean-median" test and the "efficiency gap" test to analyze the partisan fairness of the Remedial Plans.

34. The Court finds, based upon the analysis performed by the Special Masters and their advisors, that the Remedial Congressional Plan is not satisfactorily within the statistical ranges set forth in the Supreme Court's full opinion. *See Harper v. Hall*, 2022-NCSC-17, ¶166 (mean-median difference of 1% or less) and ¶167 (efficiency gap less than 7%).

35. The Court finds that the partisan skew in the Remedial Congressional Plan is not explained by the political geography of North Carolina.

IV. Remedial Senate Plan

A. The General Assembly's Starting Point and Subsequently Proposed Amendments

36. In determining the base map for the State Senate Districts, the Senate also started from scratch. The Senate altered two county groupings and adopted groupings for Senate Districts 1 and 2 that were preferred by Common Cause Plaintiffs. The remaining county groupings remained the same. As a result, the 13 wholly-contained single district county groupings in the Remedial Plan were kept from the Enacted Plan.

37. Alternative county groupings were proposed but not adopted.

a. The Senate considered the Democratic members' preferred alternate grouping for Forsyth County, which pairs it with Yadkin instead of Stokes County, but it was determined that the resulting districts in Alexander, Wilkes, Surry, and Stokes Counties would have been less compact. Additionally, Yadkin County is more Republican than Stokes County.

b. Alternative county groupings around Buncombe County were considered as well, but the Senate determined that any change from the chosen grouping would have resulted in districts that would have been significantly less compact.

38. The Remedial Senate Plan passed the Senate by a vote of 26-19. The "aye" votes in the Senate were solely by members of the Republican party, while the "no" votes in the Senate were solely by members of the Democratic Party. The Remedial Senate Plan passed the House by voice vote along party lines.

B. Analysis of Partisanship Reflected in the Remedial Senate Plan

39. The process for the development of the Remedial Senate Plan began with separate maps being drawn by the Senate Democratic Caucus and the Republican Redistricting and Election Committee members, respectively. The plans were then exchanged and discussed; however, after the two groups could not come to a resolution, the plan proposed by the Republican Redistricting and Election Committee members was then put to a vote by the Senate Committee and advanced to the full chamber.

40. The Remedial Senate Plan includes ten districts that were within ten points in the 2020 presidential race.

41. The Remedial Senate Plan reflects key differences from the 2021 Enacted Senate Plan in the projected partisan makeup of districts in certain county groupings.

a. In the Cumberland-Moore County grouping, Senate District 21 is now more competitive.

b. In the Iredell-Mecklenburg County grouping, one district is more competitive.

c. In New Hanover County, the districts were made more competitive, resulting in a Senate District 7 that leans Democratic.

d. In Wake County, Senate Districts 17 and 18 are more Democratic leaning.

42. The Court finds, based upon the analysis performed by the Special Masters and their advisors, that the Remedial Senate Plan is satisfactorily within the statistical ranges set forth in the Supreme Court's full opinion. *See Harper v. Hall*, 2022-NCSC-17, ¶166 (mean-median difference of 1% or less) and ¶167 (efficiency gap less than 7%).

43. The Court finds that to the extent there remains a partisan skew in the Remedial Senate Plan, that partisan skew is explained by the political geography of North Carolina.

C. The General Assembly's Consideration of Incumbency Protection and Traditional Neutral Districting Criteria

44. For the Remedial Senate Plan, current members of either chamber who announced retirement or their intention to seek another office were not considered as "incumbents."

45. In the Senate, incumbency was considered evenly. No Senators are double bunked unless as a result of the mandatory county groupings, and no Democratic members are double bunked with other incumbents.

46. The Court finds that the measures taken by the General Assembly for the purposes of incumbency protection in the Remedial Senate Plan were applied evenhandedly.

47. The current membership of the General Assembly was elected under a districting plan that was approved by the trial court in *Common Cause v. Lewis* and, as stated above, the General Assembly began anew the process of drawing district lines after choosing county groupings for the remedial state legislative districts in this case.

48. The Court finds that the measures taken by the General Assembly for the purposes of incumbency protection in the Remedial Senate Plan do not perpetuate a prior unconstitutional redistricting plan.

49. The Court finds that the measures taken by the General Assembly for the purposes of incumbency protection in the Remedial Senate Plan are consistent with the equal voting power requirements of the North Carolina Constitution.

50. The Court finds that the General Assembly did not subordinate traditional neutral districting criteria to partisan criteria or considerations in the Remedial Senate Plan.

V. Remedial House Plan

A. The General Assembly's Starting Point and Subsequently Proposed Amendments

51. In determining the base map for the State House Districts, the House started from scratch after keeping only the 14 districts that were the product of single district county groupings.

52. The Remedial House Plan was ultimately amended by six amendments offered by Democratic Representatives.

a. Three amendments, drawn by Representative Reives, redrew certain districts in Wake, Mecklenburg, and Buncombe, which were already Democratic leaning, to be more Democratic leaning.

b. An additional amendment, also drawn by Representative Reives, added an additional district in Cabarrus County that is more Democratic leaning.

c. An amendment offered by Representative Meyer swapped two precincts in Orange County in order to keep Carrboro whole.

d. An amendment offered by Representative Hawkins adjusted district lines in Durham County in order to better follow educational district lines.

53. The Remedial House Plan passed the House by a vote of 115-5 and was passed by the Senate by a vote of 41-3. The "aye" votes in the House and Senate were by members of both political parties. The "no" votes in the House and Senate were solely by members of the Democratic Party.

B. Analysis of Partisanship Reflected in the Remedial House Plan

54. The Remedial House Plan reflects key differences from the 2021 Enacted House Plan in the projected partisan makeup of districts in certain county groupings.

a. Buncombe County, which consisted of 1 Republican and 2 Democratic districts in the Enacted Plan, consists of 3 Democratic districts in the Remedial House Plan.

b. Pitt County, which consisted of 1 Republican and 1 Democratic district in the Enacted Plan, consists of 2 Democratic districts in the Remedial House Plan.

c. Guilford County now consists of 6 Democratic leaning districts.

d. Cumberland County now consists of 3 Democratic districts and 1 competitive district.

e. Mecklenburg and Wake Counties now consist of 13 Democratic leaning districts each.

f. New Hanover, Cabarrus, and Robeson Counties now contain an additional competitive district each.

55. The Court finds, based upon and confirmed by the analysis of the Special Masters and their advisors, that the Remedial House Plans are satisfactorily within the statistical ranges set forth in the Supreme Court's full opinion. *See Harper v. Hall*, 2022-NCSC-17, ¶166 (mean-median difference of 1% or less) and ¶167 (efficiency gap less than 7%).

56. The Court finds that to the extent there remains a partisan skew in the Remedial House Plan, that partisan skew is explained by the political geography of North Carolina.

C. The General Assembly's Consideration of Incumbency Protection and Traditional Neutral Districting Criteria

57. For the Remedial House Plan, current members of either chamber who announced retirement or their intention to seek another office were not considered as "incumbents."

58. In the House, incumbency was considered evenly. The only discretionary double bunking in the Remedial House Plan pairs two Republican members. There was no discretionary double bunking of Democratic members. The few double bunked members are double bunked solely as a result of the mandatory county groupings.

59. The Court finds that the measures taken by the General Assembly for the purposes of incumbency protection in the Remedial House Plan were applied evenhandedly.

60. The current membership of the General Assembly was elected under a districting plan that was approved by the trial court in *Common Cause v. Lewis* and, as stated above, the General Assembly began anew the process of drawing district lines after choosing county groupings for the remedial state legislative districts in this case.

61. The Court finds that the measures taken by the General Assembly for the purposes of incumbency protection in the Remedial House Plan do not perpetuate a prior unconstitutional redistricting plan.

62. The Court finds that the measures taken by the General Assembly for the purposes of incumbency protection in the Remedial House Plan are consistent with the equal voting power requirements of the North Carolina Constitution.

63. The Court finds that the General Assembly did not subordinate traditional neutral districting criteria to partisan criteria or considerations in the Remedial House Plan.

VI. Plaintiffs' Alternative Remedial Plans

64. The following alternative remedial plans for the Court's consideration were submitted by NCLCV Plaintiffs, Harper Plaintiffs, and Plaintiff-Intervenor Common Cause on February 18, 2022 (hereinafter referred to as "NCLCV Alternative Plans"; "Harper Alternative Plans"; "Common Cause Alternative Plans"; or collectively, "Alternative Plans").

65. Although Plaintiffs submitted Alternative Plans, because the Court is satisfied with the Remedial House and Senate Plans, the Court did not need to consider an alternative plan for adoption.

66. Furthermore, the Court, in following N.C.G.S. § 120-2.4(a1), has chosen to order the use of an interim districting plan for the 2022 North Carolina Congressional election that differs from the Remedial Congressional Plan to the extent necessary to remedy the defects identified by the Court.

VII. Special Masters' Interim Congressional Plan

67. As part of their Report, the Special Masters have developed a recommended congressional plan ("Interim Congressional Plan") for this Court to consider due to their findings, which the Court has adopted, that the Remedial Congressional Plan does not satisfy the requirements of the Supreme Court Remedial Order and full opinion.

68. The Court finds that the Interim Congressional Plan recommended by the Special Masters was developed in an appropriate fashion[2], is consistent with N.C.G.S. § 120-2.4(a1), and is consistent with the North Carolina Constitution and the Supreme Court's full opinion.

Based upon the foregoing findings of fact, the Court makes the following:

CONCLUSIONS OF LAW

1. In *Harper v. Hall*, 2022-NCSC-17, the Supreme Court stated:

> We do not believe it prudent or necessary to, at this time, identify an exhaustive set of metrics or precise mathematical thresholds which conclusively demonstrate or disprove the existence of an unconstitutional partisan gerrymander. *Cf. Reynolds v. Sims*, 377 U.S. 533, 578 (1964) ("What is marginally permissible in one [case] may be unsatisfactory in another, depending on the particular circumstances of the case. Developing a body of doctrine on a case-by-case basis appears to us to provide the most satisfactory means of arriving at detailed constitutional requirements in the area of . . . apportionment."). As in *Reynolds*, "[l]ower courts can and assuredly will work out more concrete and specific standards for evaluating state legislative apportionment schemes in the context of actual litigation." *Id.* However, as the trial court's findings of fact indicate, there are multiple reliable ways of demonstrating the existence of an unconstitutional partisan gerrymander. In particular, mean-median difference analysis; efficiency gap analysis; close-votes, close-seats analysis; and partisan symmetry analysis may be useful in assessing whether the mapmaker adhered to traditional neutral districting criteria and whether a meaningful partisan skew necessarily results from North Carolina's unique political geography. If some combination of these metrics demonstrates there is a significant likelihood that the districting plan will give the voters of all political parties substantially equal opportunity to translate votes into seats across the plan, then the plan is presumptively constitutional.

Id. at ¶163.

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[2] The data files (e.g., block equivalency, shape files, population deviation results) are included in the court file with this order in native format. The equivalent of the "stat pack" has been requested from the Special Masters' advisor and will be placed in the court file and provided to the parties as soon as available.

2. Plaintiffs have urged upon this court that we must adopt plans that "treat voters of both political parties fairly." They argue that the "LD Congressional and Senate Plans are not fair." Further, they argue that the Supreme Court ordered "fair maps" and that "[b]ecause the LD Congressional and Senate Plans are not fair maps, . . . the Court should adopt one of the fairer maps before it – such as the NCLCV Maps." We see Plaintiffs' arguments as tantamount to urging this Court to adopt a proportional representation standard, which the Supreme Court, in its order, specifically disavowed. *Id.* at ¶169.

3. The Court concludes that the Remedial Senate Plan satisfies the Supreme Court's standards.

4. The Court concludes that the Remedial House Plan satisfies the Supreme Court's standards.

5. Because the Court concludes that the enacted Remedial Senate and House Plans meet the Supreme Court's standards and requirements in the Supreme Court Remedial Order and full opinion, the Remedial Senate and House Plans are presumptively constitutional.

6. Furthermore, no evidence presented to the Court is sufficient to overcome this presumption for the Remedial Senate and House Plans, and those plans are therefore constitutional and will be approved.

7. The Court concludes that the Remedial Congressional Plan does not satisfy the Supreme Court's standards.

8. Plaintiffs suggest that if we conclude that a Remedial Plan passed by the General Assembly does not satisfy the Supreme Court's standards, we should simply jettison that plan and adopt one of their plans. We do not believe that our conclusion on the Remedial Congressional Plan—that it fails to satisfy the Supreme Court's standards—automatically results in the adoption of an alternate plan proposed by Plaintiffs. Given that the ultimate authority and directive is given to the Legislature to draw redistricting maps, we conclude that the appropriate remedy is to modify the Legislative Remedial Congressional Plan to bring it into compliance with the Supreme Court's order. *See* N.C.G.S. § 120-2.4(a1).

9. Because the Court concludes that the enacted Remedial Congressional Plan does not meet the Supreme Court's standards and requirements in the Supreme Court Remedial Order and full opinion, the Remedial Congressional Plan is not presumptively constitutional and is therefore subject to strict scrutiny.

10. The General Assembly has failed to demonstrate that their proposed Congressional map is narrowly tailored to a compelling governmental interest, and we therefore must conclude that the Remedial Congressional Map is unconstitutional.

11. The Interim Congressional Plan as proposed by the Special Masters satisfies the Supreme Court's standards and should be adopted by this Court for the 2022 North Carolina Congressional elections.

DECREE

BASED UPON THE FOREGOING findings and conclusions, the Court here by ORDERS the following:

1. The Remedial Senate Plan and Remedial House Plan, enacted into law by the General Assembly on February 17, 2022, are hereby APPROVED by the Court.

2. The Remedial Congressional Plan, enacted into law by the General Assembly on February 17, 2022, is hereby NOT APPROVED by the Court.

3. The Interim Congressional Plan as recommended by the Special Masters is hereby ADOPTED by the Court and approved for the 2022 North Carolina Congressional elections.

4. As the Special Masters and their retained experts may be called upon to assist this Court in this matter should the need arise in the future, the prohibition in this Court's prior order appointing the Special Masters against contacting the Special Masters or their experts remains in full force and effect.

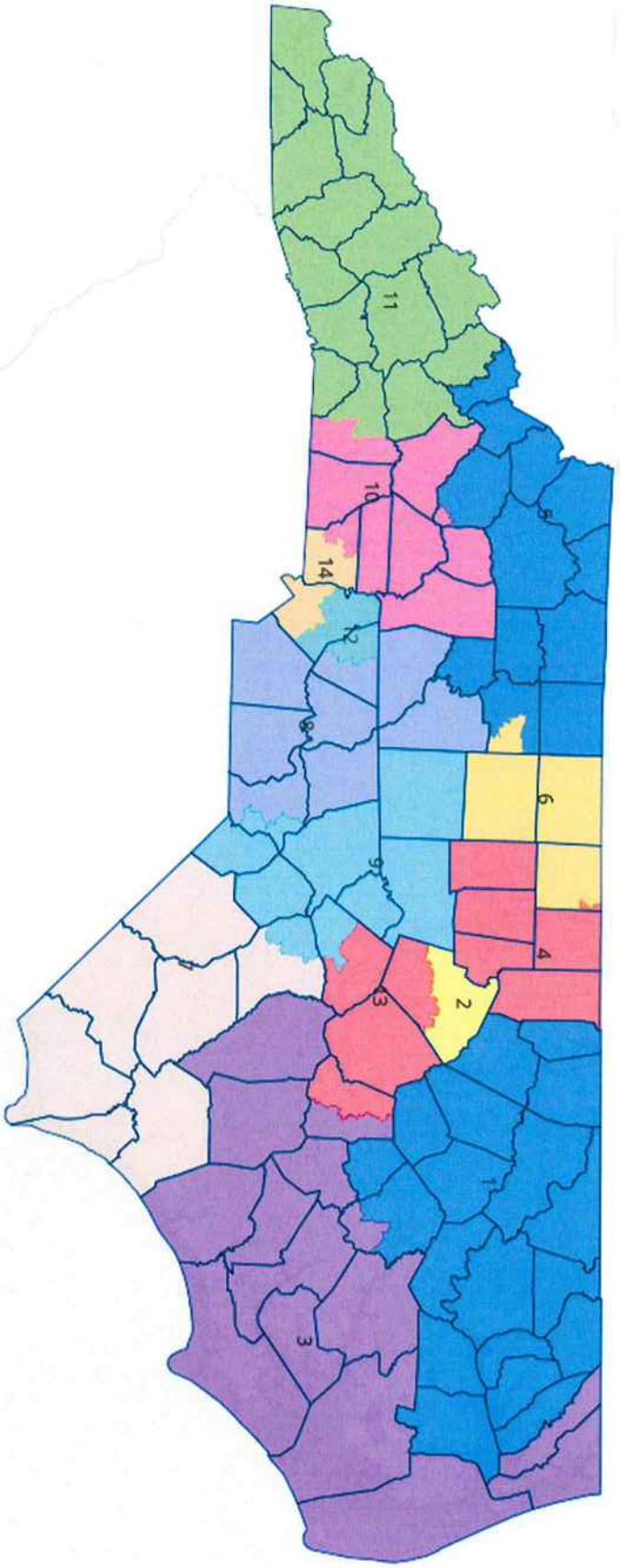
SO ORDERED, this the 23rd day of February, 2022.

A. Graham Shirley, Superior Court Judge

Nathaniel J. Poovey, Superior Court Judge

Dawn M. Layton, Superior Court Judge

Interim Congressional Plan



TO: Judges Shirley, Poovey, and Layton

FROM: Special Masters

DATE: February 23, 2022

SUBJECT: Special Masters' Report – Analysis and Recommendations

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Introduction

Pursuant to the trial court's "Order Appointing Special Masters" on February 16, 2022, ¶ 6, the undersigned now file the following report with the three-judge panel in this case.

Motion for Disqualification

In its Order Appointing the three Special Masters, the Court authorized the undersigned Special Masters (hereinafter "Special Masters") to "hire research and technical assistants and advisors reasonably necessary to facilitate [our] work." We subsequently retained Dr. Bernard Grofman, Dr. Tyler Jarvis, Dr. Eric McGhee, and Dr. Samuel Wang to assist us in satisfying our duties as Special Masters. The Curriculum Vitae for each of these individuals (hereinafter referred to as "advisors") is attached to this report. In this same Order, this Court also ordered the "parties and non-parties may not engage in any *ex parte* communication with the Special Masters about the subject matter of this litigation." *Id.*

We have been informed that Legislative Defendants have filed a motion in this case requesting that this Court disqualify Dr. Wang and Dr. Jarvis as advisors to the Special Masters and take further steps to destroy any work product completed by them and otherwise prohibit the undersigned from considering any information or materials obtained from them. We have investigated this matter and below is a detailed review of our findings.

On February 18, 2022, at 1:01 pm, Dr. Wang emailed Dr. Mattingly requesting the underlying data utilized in his analysis of the 2021 redistricting plans. On this same date at 1:57 p.m., Dr. Mattingly responded, and correspondence between Dr. Wang and Dr. Mattingly continued through February 20, 2022 at 10:23 a.m.

On February 18, 2022, at 1:21 p.m., Dr. Wang emailed Dr. Pedgen, expert for Harper Plaintiffs, seeking the underlying data Dr. Pedgen utilized in his analysis of the 2021 redistricting plans. On this same date at 2:31 p.m., Dr. Pedgen responded to Dr. Wang's inquiry, directing him to use the method utilized by Dr. Mattingly, expert for Harper Plaintiffs and Plaintiff Common Cause. On February 19, 2022, at 6:59 a.m., Dr. Wang responded to Dr. Mattingly's correspondence.

On February 19, 2022, at 4:46 p.m., Dr. Jarvis contacted Dr. Mattingly to request clarification on Dr. Mattingly's analysis and underlying data. Later that day, at 8:13 p.m., Dr. Jarvis contacted Dr. Herschlag, Dr. Mattingly's colleague at Duke University, regarding Dr. Herschlag's analysis and underlying data supporting his analysis of the 2021 redistricting plans to which Dr. Herschlag responded on that same date. All email correspondence between Dr. Wang and Dr. Jarvis and the plaintiff experts Mattingly and Pegden is attached to this report and the email correspondence attached is all of the communication that occurred between the advisors and any of the experts of the parties.

The undersigned acknowledge the technical breach of this Court's mandate that no *ex parte* communication occur between parties and non-parties with the Special Masters. The undersigned, however, respectfully recommend that the Court deny the motion for the following reasons:

- First, these communications between the advisors and Drs. Mattingly and Herschlag do not appear to have been made in bad faith and constitute the only communications between them, written or otherwise. The advisors immediately ceased contact with Drs. Mattingly and Herschlag, and have provided copies of the communications. Therefore, all parties are privy to the extent of the communications.
- Second, their communications directed at experts for Harper Plaintiffs were solely for the purpose of proceeding as quickly as possible within the abbreviated time frame allotted for the remedial process.
- Third, the Special Masters emphasize that, while the communications were in the context of the advisors' preliminary steps to evaluate the 2022 Remedial Plans, the communications sought background information pertaining to the earlier analysis of the 2021 Redistricting Plans performed by Drs. Pegden, Mattingly, and Herschlag in the merits stage of this case that was ultimately received and relied upon by the Court at trial. Additionally, as was later determined, the information sought by Dr. Wang and by Dr. Jarvis was publicly available on Dr. Hershlag's website at the time of the communications questioned herein by the Legislative Defendants.
- Finally, though the analysis provided by Drs. Wang and Jarvis was helpful and consistent with the analysis of our other expert advisors, it was not determinative of any recommendations made by the Special Masters to the court.

Review of Proposed Remedial Plans

Pursuant to the North Carolina Supreme Court's opinion, any plan with a mean-median difference of 1% or less (*Harper*, 2022-NCSC-17 at ¶ 166) and an efficiency gap below 7% (*Harper*, 2022-NCSC-17 at ¶ 167) should be considered presumptively constitutional. Additionally, as the Supreme Court recognized, other metrics may be instructive (*Harper*, 2022-NCSC-17 at ¶ 168). The Special Masters considered the full Order and Opinion of the North Carolina Supreme Court along with, the submissions from all of the parties as well as the reports of the advisors and reached the following conclusions:

I. Proposed Remedial House Plan

The advisors as well as the experts of the parties ("experts") all found the efficiency gap of the proposed remedial House plan to be less than 7%. The majority of the advisors and experts found the mean-median difference of the proposed remedial House plan to be less than 1%. In addition to these facts, the Special Masters considered the findings of the advisors on the partisan symmetry analysis, the declination metrics, and their opinions on partisan bias and evidence of partisan gerrymandering. Considering all of this information as well as the totality of circumstances, the Special Masters conclude under the metrics identified by the North Carolina Supreme Court that the proposed remedial House plan meets the test of presumptive constitutionality. Further the Special Masters did not find substantial evidence to overcome the presumption of constitutionality and recommend to the trial court that it give appropriate deference to the General Assembly and uphold the constitutionality of the remedial House plan.

II. Proposed Remedial Senate Plan

All of the advisors and experts found the efficiency gap of the proposed remedial Senate plan to be less than 7%. The majority of the advisors and experts found the mean-median difference of the proposed remedial Senate plan to be less than 1%. In addition to these facts, the Special Masters considered the findings of the advisors on the partisan symmetry analysis, the declination metrics, and their opinions on partisan bias and evidence of partisan gerrymandering. Considering all of this information as well as the totality of circumstances, the Special Masters conclude under the metrics identified by the North Carolina Supreme Court the remedial Senate plan meets the test of presumptive constitutionality. Further the Special Masters did not find substantial evidence to overcome the presumption of constitutionality and recommend to the trial court that it give appropriate deference to the General Assembly and uphold the constitutionality of the remedial Senate plan.

III. Proposed Remedial Congressional Plan

Unlike the proposed remedial House and Senate plans, there is substantial evidence from the findings of the advisors that the proposed congressional plan has an efficiency gap above 7% and a mean-median difference of greater than 1%. The Special Masters considered this evidence along with the advisors' findings on the partisan symmetry analysis and the declination metrics. There is disagreement among the parties as to whether the proposed remedial congressional plan meets the presumptively constitutional thresholds suggested by the Supreme Court. The Special Masters, considering the reports of their advisors and the experts of the parties while giving appropriate deference to the General Assembly, are of the opinion that the proposed remedial congressional plan fails to meet the threshold of constitutionality and recommend that the Trial Court reject the proposed remedial congressional plan as being unconstitutional.

Given the recommendation that the Trial Court reject the proposed remedial congressional plan, and consistent with the instructions from the three-judge panel and the Order of the Supreme Court of North Carolina, the Special Masters have submitted a modified version of the proposed remedial congressional plan submitted by the Legislative Defendants. It is our opinion that the attached plan satisfies the requirements of the Supreme Court.

The following data files for the modified congressional plan are included with this report:

1. Block equivalency files in .CSV format for each district and the plan as a whole;
2. Environmental Systems Research Institute, Inc. (ESRI) shapefiles for each district and the plans as a whole;
3. Color maps in .PDF format of the plan as a whole;
4. Population totals and deviations for each district based on the 2020 Census P.L. 94-171 dataset; and
5. Note: due to time constraints, the functional equivalent of what the General Assembly includes in its "stat pack" is not included with this report; however, if requested we will endeavor to obtain this from Dr. Grofman.

In redrawing certain district lines, the undersigned considered all of the submitted plans and related commentary. Being mindful that the Constitution of North Carolina provides that the General Assembly has the responsibility of redistricting, we focused on the proposed remedial congressional plan submitted by the Legislative Defendants. On that basis, the Special Masters worked solely with Dr. Bernard Grofman and his assistant to amend the Legislative Defendants' plan to

enhance its consistency with the opinion of the Supreme Court of North Carolina, the Constitutions of the United States and of North Carolina, and the expressed will of the General Assembly.

Dr. Grofman prepared a preliminary exemplar map at the Special Masters' request and thereafter at the instruction of the Special Masters prepared three maps for consideration. One of these maps raised potential VRA concerns and so was discarded. A second map did not meet the 1% threshold for mean-median difference and so was likewise discarded. The Special Masters then modified the third prepared map in order to improve the efficiency gap and mean-median difference scores as well as compactness and contiguity measures.

The following parties were involved in the process of redrawing the plans:

a. Robert F. Orr
b. Robert H. Edmunds, Jr.
c. Thomas W. Ross
d. Dr. Bernard N. Grofman
e. Zachary R. Griggy (Research Assistant to Dr. Grofman)
f. Adam H. Steele, Senior Judicial Fellow (for administrative purposes only)
g. Alison J. Rossi, Judicial Fellow (for administrative purposes only)
h. Danielle Smith, Judicial Fellow (for administrative purposes only)

Dave's Redistricting App was used in the redrawing of the plan.

The Special Masters believe the modified congressional plan recommended for adoption to the Trial Court achieves the partisan fairness and "substantially equal voting power" required by the Supreme Court of North Carolina without diluting votes under the Voting Rights Act while maintaining the number of county splits, retaining equal population, compactness, and contiguity, as well as respecting municipal boundaries. Dr. Grofman's analysis of the modified congressional plan recommended by the Special Masters indicates that the plan has an efficiency gap of 0.63%, a mean-median difference of 0.69%, seat bias of 0.28%, and vote bias of 0.10%. According to Dr. Grofman, "this is the most non-dilutive plan in partisan terms of any map that has been submitted to the Court."

Accordingly, the Special Masters recommend to the Trial Court that it order the State of North Carolina to utilize the modified congressional plan prepared by the Special Masters in the 2022 Congressional election.

This the 23rd day of February 2022.

Robert H. Edmunds, Jr.

Robert F. Orr

Thomas W. Ross

Acknowledgement

We would like to thank the advisors, Dr. Grofman, Dr. Jarvis, Dr. McGhee, and Dr. Wang for their analysis and advice in the extremely compressed timeframe. Additionally, we would like to thank the Judicial Fellows, Adam Steele, Alison Rossi, and Danielle Smith for their administrative support and assistance in preparing this report and for the long hours of work in bringing this matter to a conclusion.

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing document was served on the persons indicated below via electronic transmission by e-mail addressed as follows:

Burton Craige
Narendra K. Ghosh
Paul E. Smith
PATTERSON HARKAVY LLP
100 Europa Dr., Suite 420
bcraige@pathlaw.com
nghosh@pathlaw.com
psmith@pathlaw.com
Counsel for Harper Plaintiffs

Stephen D. Feldman
Adam K. Doerr
Erik R. Zimmerman
ROBINSON, BRADSHAW & HINSON, P.A.
434 Fayetteville Street, Suite 1600
Raleigh, NC 27601
sfeldman@robinsonbradshaw.com
adoerr@robinsonbradshaw.com
ezimmerman@robinsonbradshaw.com
Counsel for NCLCV Plaintiffs

Allison J. Riggs
Hilary H. Klein
Mitchell Brown
Katelin Kaiser
Jeffrey Loperfido
SOUTHERN COALITION FOR
SOCIAL JUSTICE
1415 W. Highway 54, Suite 101
Durham, NC 27707
allison@southerncoalition.org
hilaryhklein@scsj.org
mitchellbrown@scsj.org
katelin@scsj.org
jeffloperfido@scsj.org
Counsel for Common Cause Plaintiff-Intervenor

Phillip J. Strach
Thomas A. Farr
Alyssa M. Riggins
John E. Branch, III
NELSON MULLINS RILEY &
SCARBOROUGH LLP
4140 Parklake Avenue, Suite 200
Raleigh, NC 27612
Phillip.strach@nelsonmullins.com
Tom.farr@nelsonmullins.com
Alyssa.riggins@nelsonmullins.com
John.Branch@nelsonmullins.com
Counsel for Legislative Defendants

Terence Steed
Amar Majmundar
Stephanie A. Brennan
NORTH CAROLINA DEPARTMENT
OF JUSTICE
Post Office Box 629
Raleigh, NC 27602
tsteed@ncdoj.gov
amajmundar@ncdoj.gov
sbrennan@ncdoj.gov
Counsel for State Board Defendants

Service is made upon local counsel for all attorneys who have been granted pro hac vice admission, with the same effect as if personally made on a foreign attorney within this state.

This the 23rd day of February 2022.

Kellie Z. Myers
Court Administrator - 10th Judicial District
Kellie.Z.Myers@nccourts.org

To: Special Masters, North Carolina Superior Court, Wake County

From: Eric McGhee

Re: Remedial state senate maps in *NCLCV* v *Hall* and *Harper* v *Hall*

Date: February 20, 2022

The Special Masters appointed by the North Carolina Superior Court of Wake County have asked me to provide my assessment of the partisan fairness of the remedial maps submitted by the parties to *NCLCV* v *Hall*, and *Harper* v *Hall*. I am a political scientist who studies elections, election administration, redistricting, public opinion, and legislative behavior. I am the creator of a popular measure of partisan gerrymandering called the efficiency gap, and co-creator with Nicholas Stephanopoulos of Harvard University of a legal test using the same. I am also a member of the Board of Directors of PlanScore, a nonpartisan website that scores redistricting plans on measures of partisan advantage. I have numerous published articles on the subject of partisan advantage in redistricting and am frequently consulted on the topic by policymakers and the media. I have a PhD in political science from the University of California, Berkeley.

In this memo I will evaluate the remedial state senate maps against each other and against the original enacted maps that were struck down. I will use four measures of partisan advantage: partisan symmetry (PS), the mean-median difference (MMD), the efficiency gap (EG), and the declination (D). I will also offer some evidence of the competitiveness of each plan, the compactness of the districts, and how many counties have been split.

In an earlier memo (mcghee_nc_remedial_metrics.pdf) I described the logic behind each of the fairness metrics, so I direct the reader to that memo for further information and I will not cover that topic here. However, it is worth mentioning that PS and MMD have special significance for this state legislative analysis. The two metrics offer a sense of how difficult it would be for a party with majority voter support to control a majority of the seats. Majority control of North Carolina's congressional delegation does not by itself dictate majority control of the U.S. House of Representatives. But majority control of state legislative seats *does* decide which party organizes chambers of the state legislature. This gives the PS and MMD a clearer nexus to the fair allocation of political power for state legislature in a competitive state like North Carolina, where majority support is a live issue.

I will use PlanScore to conduct the great majority of this analysis. In an earlier memo analyzing the congressional plans (mcghee_nc_remedial_congress.pdf) I offered an explanation of PlanScore's approach

to estimating partisan outcomes, so I direct the reader to that memo for most of the details on that topic. In my analysis of the congressional plans I mentioned that PlanScore also reports EG values using presidential and U.S. Senate votes, without any statistical modeling. I prefer the model predictions, but I will note how the presidential and U.S. Senate values compare for each of the plans.

The *Stephenson* rule

In North Carolina redistricting, the *Stephenson* rule controls how many counties may be split across multiple districts. Counties are grouped together before any lines are drawn, and boundaries are chosen within each of these county groups. In this particular litigation it appears that both sides agree on the parameters of the Stephenson constraint, so the precise groupings of counties is not at issue in this case.

The *Stephenson* rule does not fundamentally change the partisan fairness evaluation I will conduct here. The partisan fairness metrics used in this memo can tell us which party is advantaged by a plan, but not whether that advantage can be avoided without running afoul of other legal constraints like the *Stephenson* rule. That question can only be answered by identifying one or more alternative plans that *do* successfully avoid the bias. These plans might be submitted by other parties, or they might be generated randomly by a computer through an ensemble analysis that programs the *Stephenson* rule into its algorithm.

It is tempting to think that the *Stephenson* rule requires breaking the partisan fairness evaluation into a series of separate assessments, one for each county group. It certainly breaks up line drawing this way. But the fairness metrics are always a *plan-wide* consideration, because the overall effect is what matters for the allocation of political power and so for fairness. To evaluate each county group separately would be akin to deciding the winner of a basketball game by counting the number of quarters won by each team: it might say something about which team played better, but would miss the main point of the game.

Partisan fairness

Table 1 contains a comparison of PlanScore results for the original enacted plans that were struck down and each of the proposed remedial plans. The columns headed "Open" contain predictions that simulate what might happen if no incumbents ran for reelection and every seat was open. The columns headed "Incumb." place incumbents in the seats they were drawn into and treat as open any seat where the Legislative Defendants indicated the incumbent was retiring (see footnote 11 on p. 21 of the file "22.02.18 -

LD Memo re Remedial Maps and Related Materials.pdf").[1] The difference between these columns in each case is the effect of incumbency on the outcome.

The PlanScore pages for these results can be found at each of the links below:

- **Enacted**
  - Open
  - Incumbent
- **Legislative Defendants**
  - Open
  - Incumbent
- **NCLCV**
  - Open
  - Incumbent
- **Harper**
  - Open
  - Incumbent

The metrics are on different scales (see the memo on metrics) so the best way to understand the values is to compare the plans to each other on the same metric, to compare the direction of the bias across different measures of the same plan, and to see how likely those directions are to persist over the life of the plan. To facilitate this last evaluation, I have added an asterisk (∗) to those values that are likely to favor the same party over all five elections of the plan according to the model.

The original enacted plan is the most biased of the ones considered here, with similar Republican advantages when every seat is open (EG: 7.0%; MMD: 3.6%; PS: 7.3%; D: 0.30) and when incumbents are running (EG: 6.9%; MMD: 4.3%; PS: 7.5%; D: 0.32). These advantages would all be highly likely to favor Republicans throughout the decade. The MMD and PS values suggest the Democrats would find it difficult to win a majority of the seats without an extraordinary majority of popular support.

[1] A note is in order on "double bunking," where more than one incumbent has a residence in the same district. When at least one Republican and one Democrat were double bunked, I treated these incumbency effects as offsetting, making the district functionally open for the purposes of the analysis. This occurred in District 37 in the Legislative Defendants' plan and District 21 in the Harper plaintiffs' plan. When only incumbents of the same party were double bunked, I treated such districts as having one incumbent of the doubled-bunked party. Every submission had at least one doubled-bunked district of this type.

Table 1: Legislative Defendants' plan is fairer than enacted plans but not plaintiff submissions

	Efficiency Gap		**Mean-Median Diff.**		**Symmetry**		**Declination**	
	Open	Incumb.	Open	Incumb.	Open	Incumb.	Open	Incumb.
Enacted	$7.0R^*$	$6.9R^*$	$3.6R^*$	$4.3R^*$	$7.3R^*$	$7.5R^*$	$0.30R^*$	$0.32R^*$
Legislative Defendants	$4.8R^*$	$4.5R^*$	$2.2R^*$	$3.0R^*$	$4.8R^*$	$5.1R^*$	$0.20R^*$	$0.20R^*$
NCLCV	$2.6R$	$2.2R$	$1.1R$	$1.3R$	$2.3R$	$2.4R$	$0.10R$	$0.10R$
Harper	$2.2R$	$2.4R$	$0.8R$	$1.4R$	$1.9R$	$2.6R$	$0.08R$	$0.11R$

Note: "Open" values are predictions from the PlanScore model that simulate an election where all incumbents stepped down and every seat was open. "Incumb." values assume incumbents will run in the district that contains their home residence. The districts containing the residences of the incumbents who are retiring—according to the Legislative Defendants—are treated as open in both calculations. * = value that is more than 50% likely to favor the same party over the course of the decade, using the uncertainty estimates from the PlanScore model.

The Legislative Defendants' remedial plan still favors Republicans when all seats are open, but somewhat less (EG: 4.8%; MMD: 2.2%; PS: 4.8%; D: 0.20). The EG value now clearly falls below the commonly identified threshold of 7%, though the MMD value falls well above the 1% number cited by the Legislative Defendants (see p. 7 of their brief). The values with incumbency factored in are substantially similar (EG: 4.5%; MMD: 3.0%; PS: 5.1%; D: 0.20). All the metric values for both the open seat and incumbency scenarios are more than 50% likely to favor Republicans throughout the decade. The model-free calculations using presidential and U.S. Senate votes are very similar to the PlanScore model results for this plan.

The remaining two remedial plans in Table 1 are very similar to each other on these metrics. The values are only fractionally different within the open seats and incumbency scenarios. Like the other plans in Table 1, these also favor Republicans in all cases. However, this Republican advantage is often less than half the size of the same advantage in the Legislative Defendants' plan. Neither of the plaintiffs' submissions is more than 50% likely to favor Republicans throughout the decade on any of the metrics. However, the MMD and PS values in the Harper plaintiffs' submission are close to 50% in the incumbency scenario, with probabilities higher than 40% in both cases. Once again, the model-free calculations with presidential and U.S. Senate votes are very similar to the numbers presented here.

Competition and traditional geography

In addition to these questions of partisan fairness, it is possible to evaluate the maps in terms of competitiveness and respect for traditional geography.

A plan can favor one party but have more or fewer competitive seats. PlanScore identifies districts that are more than 50% likely to switch party hands at least once in the five elections under the plan. As a practical matter, this works out to districts with expected two-party vote shares between about 45 and 55 percent.

For traditional geography, I look at two dimensions of the issue. The first is compactness: the extent to which the districts resemble a simple shape like a circle. I capture this concept with two different metrics: the Reock score and the Polsby-Popper score. Neither is dispositive of compactness, but they tend to capture some sense of what is meant by the concept and they are correlated with each other. I also report the total number of counties that have have been split across multiple districts, as reported by Dave's Redistricting App.

Table 2: Competition and compactness are largely similar across remedial plans

	Competitive Seats		**Compactness**		
	Open	Incumb.	Reock	Polsby-Popper	**Split Counties**
Enacted	9	7	0.42	0.34	15
Legislative Defendants	10	7	0.43	0.38	15
NCLCV	11	9	0.43	0.37	15
Harper	12	10	0.41	0.35	15

Note: "Open" values are predictions from the PlanScore model that simulate an election where all incumbents stepped down and every seat was open. "Incumb." values assume incumbents will run in the district that contains their home residence. The districts containing the residences of the incumbents who are retiring—according to the Legislative Defendants—are treated as open in both calculations. "Competitive Seats" are those more than 50% likely to favor the same party over the course of the decade, using the uncertainty estimates from the PlanScore model. The Reock and Polsby-Popper compactness scores both range from zero for not compact to one for maximally compact. "Split Counties" is the number of counties that have been divided into more than one district, as identified in Dave's Redistricting App.

Table 2 has the results. The enacted plan has the fewest competitive seats when all seats are open (9), followed by the Legislative Defendants' plan (10), the NCLCV plan (11), and the Harper plaintiffs' plan (12). Incumbents bring the number of competitive seats down somewhat, and there emerges a modest distinction between the number for the enacted and Legislative Defendants' plans (7 each), and the number

in the NCLCV (9) and Harper plaintiffs' (10) plans.

Likely reflecting the constraints of the *Stephenson* rule, all four plans do a reasonably good job of respecting traditional geographic principles. All four have very similar compactness on both measures considered here, and each splits 15 counties.

Conclusion

Much like with the congressional submissions, the Legislative Defendants' remedial senate plan appears to fall in between the original enacted plan and the plaintiffs' remedial proposals on the fairness metrics. The MMD and PS metrics, which are more relevant for a state legislative plan because they connect directly to control of the chamber, suggest that in a tied election Republicans would still hold 27 or 28 seats, and that Democrats would need to win as much as 53 percent of the vote to claim 25 seats. The odds are about three to one that Republicans would maintain this advantage throughout the decade. Over the course of the last decade, Republicans managed to win 53 percent of the state senate vote once, while the most Democrats achieved was just over 50 percent.

In the plaintiffs' submissions, Republicans would win about 26 seats in a tied election, and Democrats would need about 51 percent of the vote to tie Republicans at 25 seats. The odds are about two to one or better that Republicans would lose this advantage at some point over the next decade. This suggests that there is nothing foreordained about the advantages in the Legislative Defendants' plan. The question would seem to turn instead on whether the Legislative Defendants' plan is to be preferred for other reasons.

There is far less difference between the plans in competitiveness or traditional geographic criteria. The plans are virtually identical on geography, and while the number of competitive seats is lower in the enacted and Legislative Defendants' plans, the difference is small.

ADVISORY REPORT TO SPECIAL MASTERS ON PROPOSED REMEDIAL REDISTRICTING PLANS FOR NORTH CAROLINA

Tyler J. Jarvis*
February 22, 2022

Contents

*I am a Professor of Mathematics at Brigham Young University. I have a Ph.D and master's degree in mathematics from Princeton University. I lead a research group at Brigham Young University that conducts non-partisan research to understand and quantify partisan gerrymandering. I have previously consulted on quantifying gerrymandering for the Utah Independent Redistricting Commission. I was assisted in the analysis done in this report by Annika King, Jacob Murri, William Terry and Broderick Craig, all of whom worked under my direction.

1. Overview

I was asked to perform an ensemble analysis of eight proposed remedial plans: two (Congressional and Senate) from the Harper plaintiffs, and three each (Congressional, House, and Senate) from NCLCV and the legislative defendants.

Ensemble analysis consists first of constructing a large number of possible alternative plans (the ensemble). The plans are generated without using any partisan information, but in accordance with accepted criteria for redistricting in the state, including approximately equal population per district, contiguity of districts, relative compactness of districts, few boundary traversals, and so

forth. Historical election data is then used to compare election results under the proposed plans with elections results under the ensemble.

I was asked to include the following well-known metrics in my ensemble analysis: mean–median (MM), efficiency gap (EG), partisan bias (PB), and declination (D). All of these have the property that a more negative score is supposed to represent more benefit to Republicans and a more positive score is supposed to represent more benefit to Democrats. Scores closer to zero are generally expected to be less indicative of a partisan gerrymander.

But the range of possible scores also varies widely from state to state because of widely varying political geography from state to state, varying criteria for redistricting, and varying results from different elections. Although one might make a philosophical argument for why scores for a given metric that lie outside a given range should be considered evidence of a partisan gerrymander, this is an unreasonable standard if all or most of the possible scores lie outside that range. Indeed, in some cases it may not even be possible for the scores in a given state under a given set of redistricting rules to lie in that prescribed range.

Ensembles provide important context for interpreting these scores by helping to identify a typical range of score values as well as identifying outliers.

1.1. **Ensembles.** The best way to do an ensemble analysis is to generate an ensemble with a distribution of plans that specifically reflects the redistricting criteria for case under consideration. But doing that properly takes much more time than is available. Because of this I chose to use ensembles previously generated by Professor Jonathan Mattingly and his collaborators at Duke University [1]. These were generated using well-accepted MCMC methods.

My analysis is conditioned on the assumption that these ensembles are somewhat representative of the distribution of possible plans reflecting established law and intent of the court. In the case of the Congressional ensemble, I am more confident of this for the Congressional ensemble than in the case of the House and Senate ensembles. I discuss this in more detail in Sections 2.2, 3.1, and 4.

1.2. **Election Data.** For all three types of plans (congressional, senate, and house) I used historical results from the following 11 elections: the 2016 Attorney General (G16AG), Presidential (G16PR), Lieutenant Governor (G16LG) and Governor (G16AG), as well as the 2020 Attorney General (G20AG), Presidential (G20PR), Lieutenant Governor (G20LG), 2020 Governor (G16AG), Treasurer (G20TR), US Senate (G20USS), and Secretary of State (G20SST). To calculate the vote shares and other scores for the proposed plans, I used 2016 and 2020 precinct-level election results from the Voting and Election Science Team (VEST) and prorated the data to 2020 census blocks.

1.3. **Racial Considerations.** It is important to note that I have not considered racial factors or the VRA in this analysis. Incorporating those considerations may lead to other conclusions than those I have drawn here.

2. Congressional Plans Analysis

Using data from the 11 different historical elections mentioned above, I evaluated three congressional plans: one each from the Harper plaintiffs (Harper), NCLCV, and the legislative defendants (LD). I also analyzed the number of seats that would have been won under these various vote counts and the margins of victory in the most contested districts.

2.1. **Summary of Congressional Analysis.** My analysis below shows that, by all the measures I used, the LD plan favors Republicans more than the other two plans do, the NCLCV plan favors Democrats more than the other two plans, and the Harper plan lies somewhere between them. Both the LD and Harper plans are fairly typical in the ensemble distributions for all the measures I considered. The NCLCV plan, however, shows up as a significant outlier for the seat margins

for competitive seats (see Section 2.4) as well as for the mean–median and partisan bias scores. Taken together these give some evidence of partisan gerrymandering in the NCLCV congressional plan.

These conclusions do not take VRA racial considerations into account.

2.2. **Ensemble.** For analyzing the congressional plans I used the ensemble [2] (sometimes denoted the *Duke* congressional ensemble in this report). According to my reading of [4], this ensemble is generated using well-accepted Markov chain Monte Carlo methods (a parallel tempering framework using a proposal from the Multiscale Forest RECOM algorithm). Under this method specific parameters for the distribution to enforce certain requirements and to encourage certain properties of the plans chosen. According to [4] the resulting plans split no more than 14 counties and split no county into more than two districts. All districts are required to consist of one contiguous region. The deviation of the total population in any district is within 1% of the ideal district population. Districts traverse counties as few times as possible, and plans with a higher Polsby–Popper score (more compact) are more likely to be selected. This model was tuned to give similar Polsby–Popper score to the enacted congressional plan. Some have argued that tuning for a specific range of Polsby–Popper scores might skew the distribution somewhat, but in my own (unpublished) research I have explicitly checked for correlation between Polsby–Popper scores and metrics of partisan bias in ReCom MCMC and found none. I expect that this absence of correlation would hold in the other ReCom-based MCMC methods as well, including the method used to generate this ensemble. The ensemble has nearly 80,000 plans, and according to [4] the distribution seems well mixed has been sufficiently sampled to provide stable statistics. I cannot verify the mixing directly, but in my use of the ensemble, I saw no signs that the ensemble was not well mixed. Based on these I conclude that this ensemble is suitable to evaluate the Congressional plans.

2.3. **Distribution of Seats Across Elections.** Different plans perform differently under different elections. When a plan gives more seats to one party than most of the plans in the ensemble do, that can suggest a possible partisan gerrymander, especially when this occurs over several elections. To analyze this, I used histograms of seats won for the ensemble for each race, collected in Figure 1.

These histograms show that while the LD plan consistently favors Republicans and the the Harper plan consistently favors Democrats, in both cases the number of seats they give in most races is fairly typical of the ensemble distribution. The NCLCV plan also consistently favors Democrats, usually much more so than the Harper plan, and in one case (G20PR) more so than 99.7% of the ensemble, making it a significant outlier in that election.

An alternative view of the same data collected into one diagram, with histograms replaced by violin plots, is shown in Figure 2.

2.4. **Rank-Ordered Violin Plots.** The number of seats won by a plan in an election does not indicate how close the election would be. A plan that gives Democrats 51% of the vote share in their winning districts is very different from one that gives them 70% of the vote share in those districts. To analyze this effect for the proposed plans I used rank-ordered violin plots; see Figures 3 and 4. In a rank-ordered violin plot for a given election, all the congressional districts for each plan are ordered left-to-right by their Democratic vote share in the election. The numbers on the horizontal axis represent the position of the district in rank ordering (not the name given to the district in the plan). The vote share for the plans in the ensemble is represented by the gray violin-shaped distributions in each distribution, and the vote share for each plan is indicated by the corresponding colored bar.

Figure 3 shows a rank-ordered violin plot for the election G20LG, which reveals that although the NCLCV plan gives one more seat (District 8 in the figure) to the Democrats than the Harper plan, that extra seat comes by a very fine margin, with the NCLCV plan just over 50% and the Harper plan just under 50% in that district. None of the plans is a far outlier compared to the

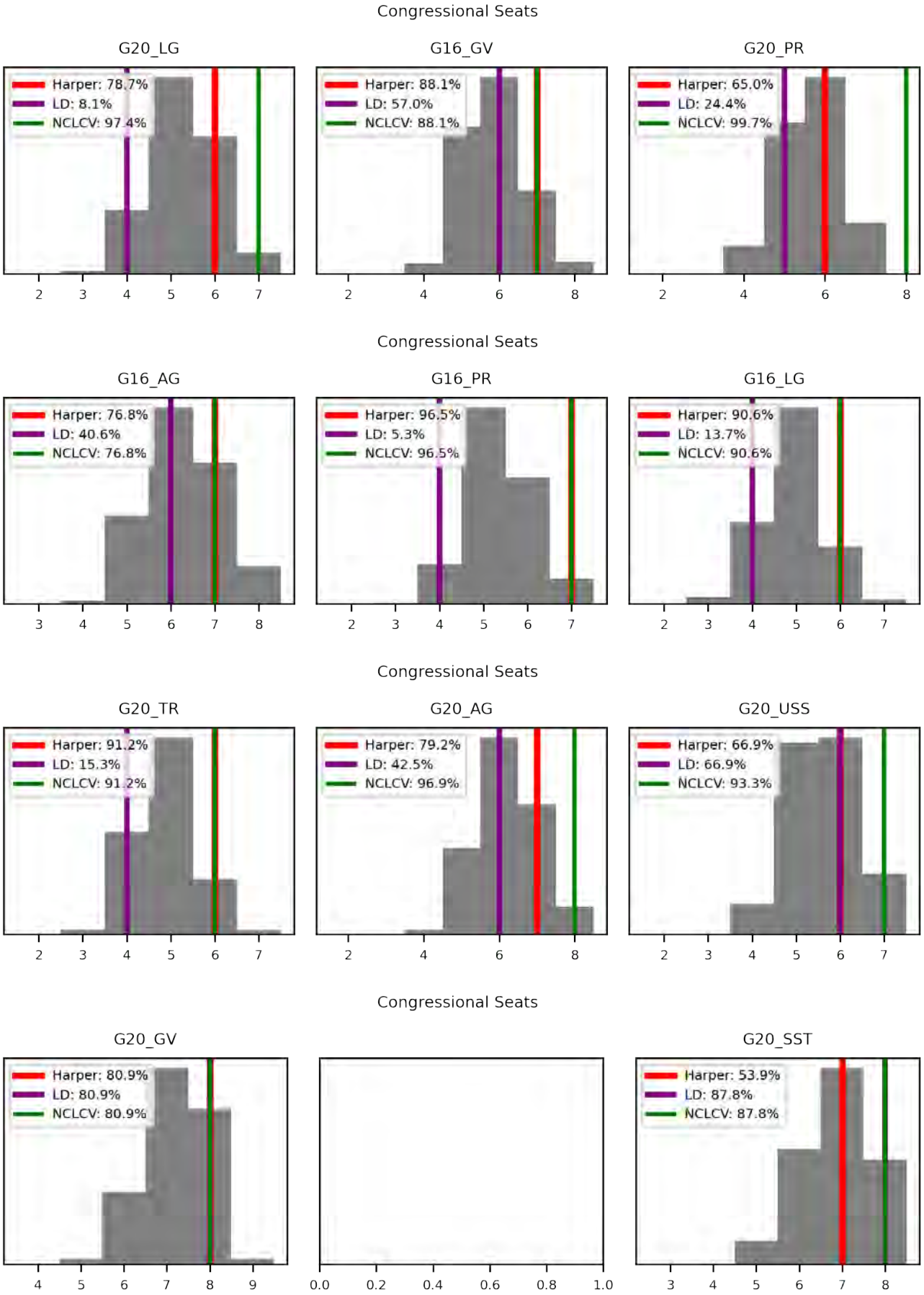

FIGURE 1. Histograms of congressional seats won in all 11 elections for the ensemble plans (gray). The proposed plans are indicated as colored vertical lines.

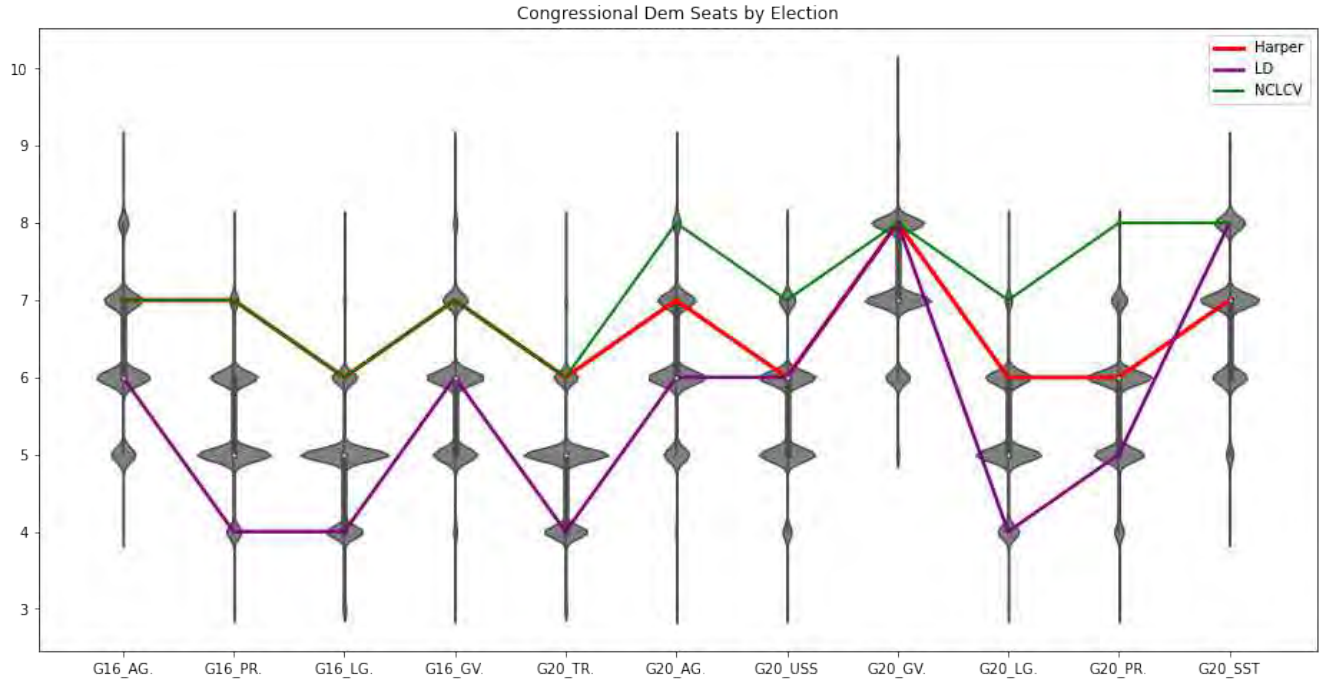

FIGURE 2. Congressional seats won across elections: shows the number of seats won (vertical axis) by Democratic candidates under each plan (colored lines) over the 11 elections (horizontal axis). The ensemble distribution of seats won for each election is indicated with the gray "violins," with wider gray regions around a point indicating more ensemble plans with the indicated number of seats won, and narrower regions indicating fewer ensemble plans with the indicated number of seats won.

ensemble in this district. This suggests that the difference in the number of seats between NCLCV and Harper in this election is not significant.

However, in this election the NCLCV plan makes District 7 much more competitive (favoring the Democrats) than either the Harper or LD plans do. Although NCLCV does not actually give the seat in District 7, NCLCV gives this district a much higher Democratic vote share than either Harper or LD and, more significantly, much higher than most of the ensemble. This makes that district very close to a win for the Democrats, without actually giving the seat to them.

Taken together, Figures 4 and 3 show that in seven of the elections (G20LG, G20GV, G20AG, G20US, G20TR, G20PR, and G16GV) the NCLCV plan places the Democratic vote share in this borderline district (7) substantially higher than most of the ensemble, which either gives the seat to the Democrats or nearly gives them the seat, by pushing the Democratic vote share close to 50%. The other plans (Harper and LD) stay in a fairly typical part of the ensemble distribution across all elections. I take this as some evidence of partisan gerrymandering in the NCLCV plan, but not in the LD and Harper plans.

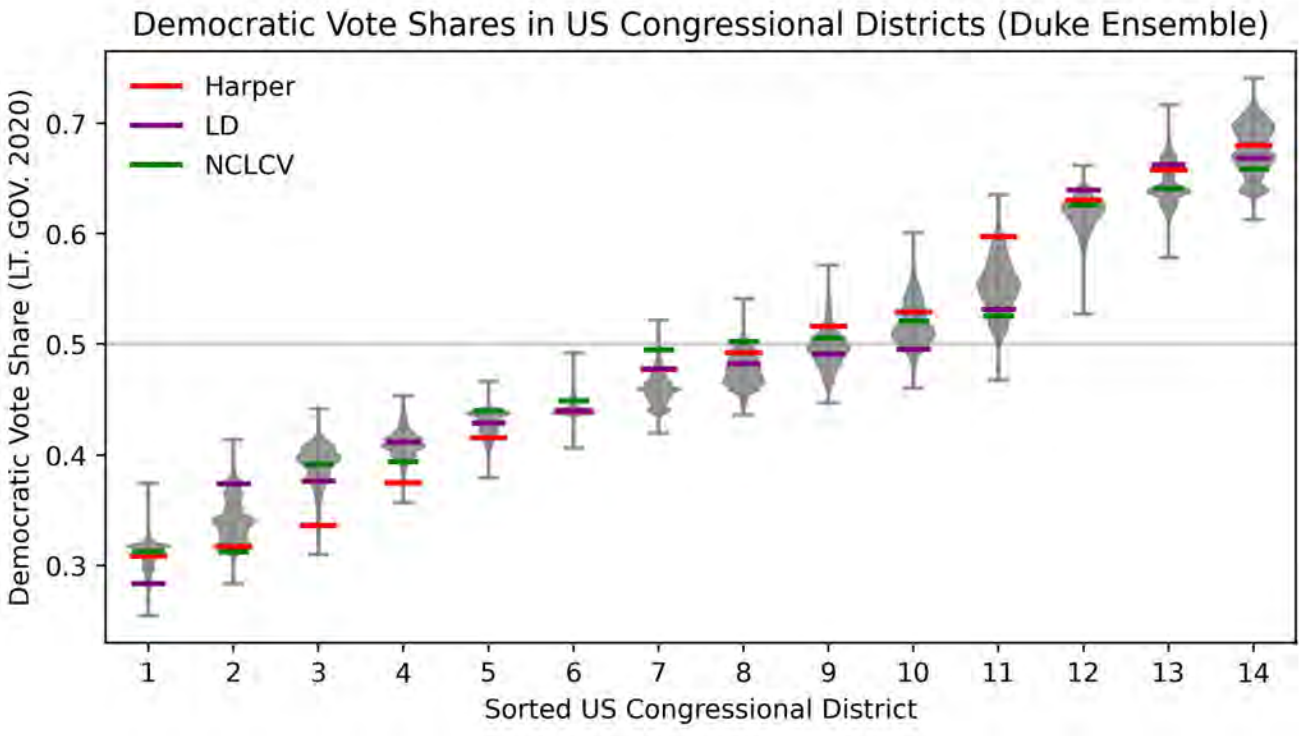

FIGURE 3. For each plan, all the congressional districts (horizontal axis) are ordered left-to-right by their Democratic vote share in the G20LG election. The numbers on the horizontal axis represent the position of the district in rank ordering (not the number given in the proposal). The vote share for the plans in the ensemble is represented by the gray violin-shaped distributions in each distribution, and the vote share for each plan is indicated by the corresponding colored bar. Points above the gray 50-percent line indicate a seat that goes to the Democrats and those below go to the Republicans.

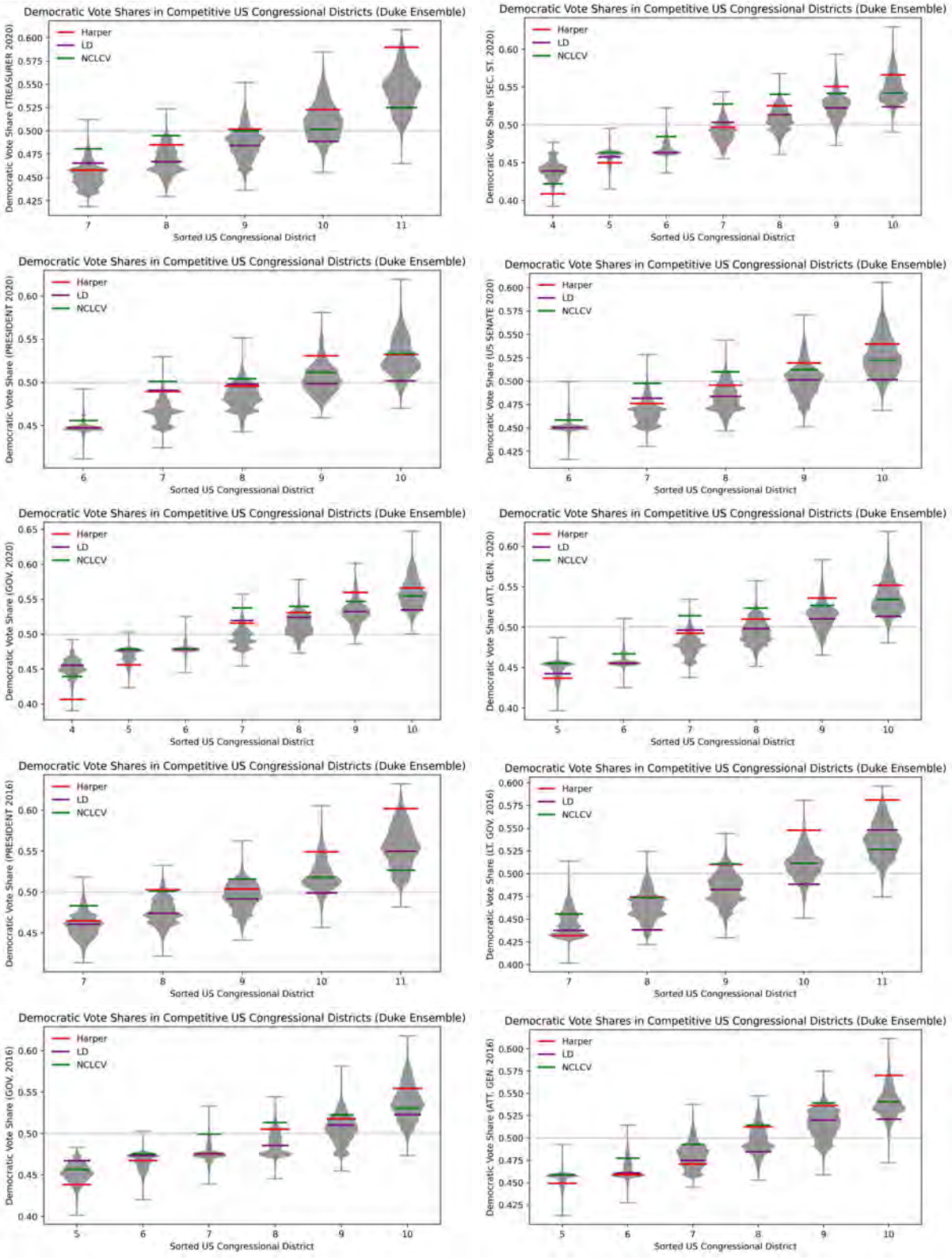

FIGURE 4. Rank-ordered congressional districts for all the elections except G20LG (shown above in Figure 3). These plots show only the most competitive districts.

2.5. **Other Metrics.** I also analyzed the plans using the mean–median score, partisan bias score, efficiency gap, and partisan declination. The first three scores are well-known and widely used. The declination is a relatively new measure proposed by Warrington. All four measures are reviewed in [5], so I will not describe them in detail here. All four of them give a single score for which a more negative score is supposed to represent more benefit to Republicans and a more positive score is supposed to represent more benefit to Democrats. Scores closer to zero are generally expected to be less indicative of a partisan gerrymander, but that depends heavily on the political geography of the state, so it is important to interpret these scores in the context of ensembles.

In the ensemble analysis below, all four scores show the LD plan favors Republicans more than the other two plans do, the NCLCV plan favors Democrats more than Harper or LD, and the Harper plan lies somewhere between them. Both the LD and Harper plans are fairly typical in the ensemble distributions for all four scores across almost all elections. The NCLCV plan, however, shows up as a significant outlier the mean–median and partisan bias scores.

2.5.1. *Mean–Median.* Table 1 shows my calculations of the mean–median scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

As shown in Figure 5 the mean–median score consistently identifies the LD plan as favoring Republicans more than the others but it is still not an outlier for the ensemble distribution. The Harper plan is is also not an outlier for the ensemble. The NCLCV plan is identified as favoring Democrats more than the others (higher scores) and is a significant outlier (greater than 99th percentile) in six of the elections.

2.5.2. *Partisan Bias.* Table 2 shows my calculations of the partisan bias scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

As shown in Figure 6, the partisan bias score also consistently identifies the LD plan as favoring Republicans more than the others but overall is more typical of the distribution than either of the other two plans. The NCLCV plan is identified as favoring Democrats more than the others and is on the very high end (over 97th percentile) of the ensemble distribution in many of the elections.

2.5.3. *Efficiency Gap.* Table 3 shows my calculations of the efficiency gap scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

As shown in Figure 7 the LD and Harper plans are mostly typical for the distribution of efficiency gap across elections. The the NCLCV plan is a significant outlier in one election (G20PR), and is somewhat high (above 90th percentile) for three other elections.

2.5.4. *Declination.* Table 4 shows my calculations of the declination scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

As shown in Figure 8 the declination only marks the NCLCV plan as a significant outlier (over 99%), but all three plans are on the outer edges (above 90% or below 10%) for some of the elections.

2.6. **Congressional Conclusion.** Both the LD and Harper plans are fairly typical in the ensemble distributions for all the measures I considered. The NCLCV plan, however, shows up as a significant outlier for the seat margins for competitive seats (see Section 2.4) as well as for the mean–median and partisan bias scores. Taken together these give evidence of partisan gerrymandering in the NCLCV congressional plan, but VRA racial considerations, which I have not considered here, might change that conclusion.

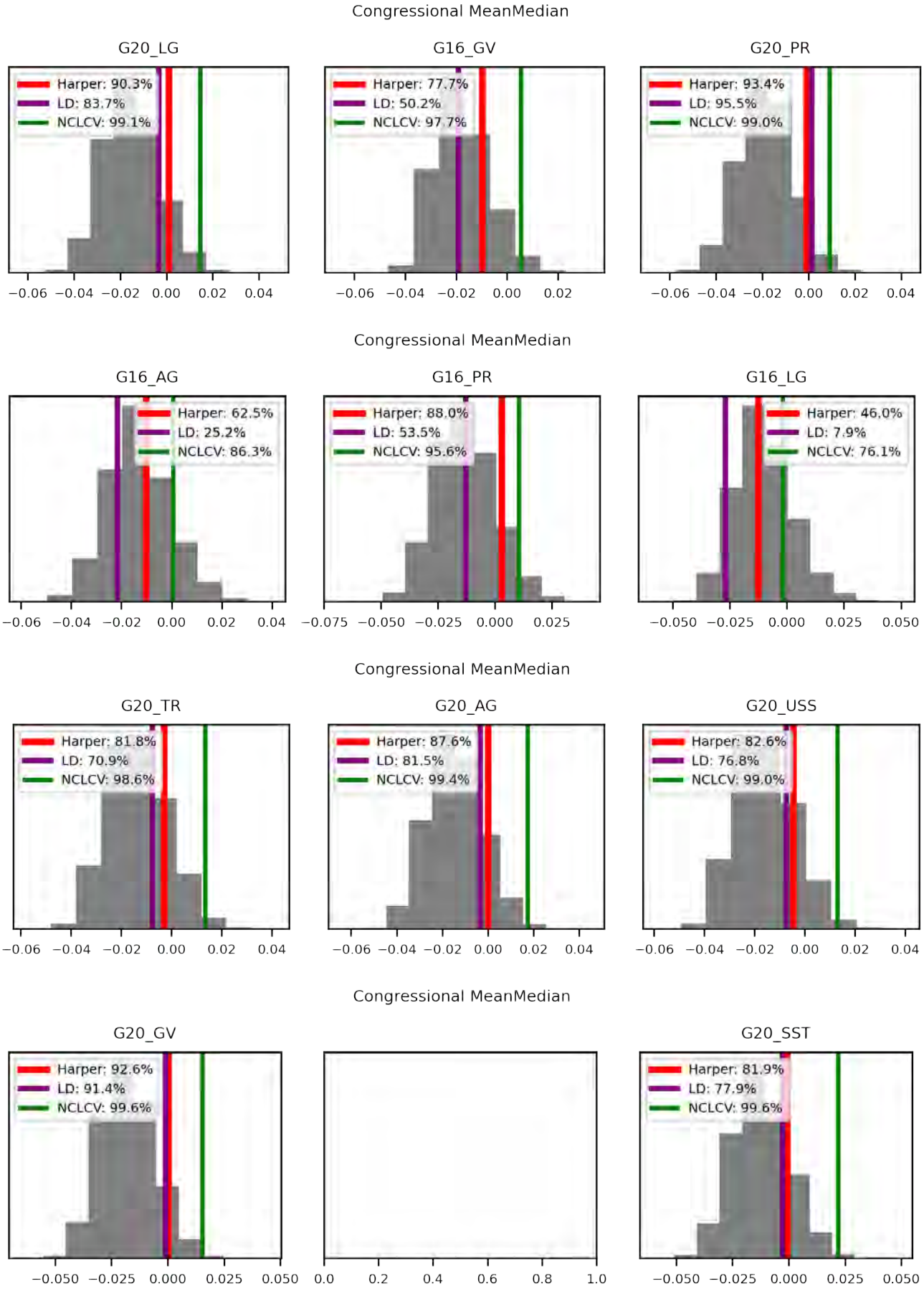

FIGURE 5. Histogram of congressional mean–median score for all 11 elections. The percentages in the legend represent percentile of the corresponding score in the ensemble.

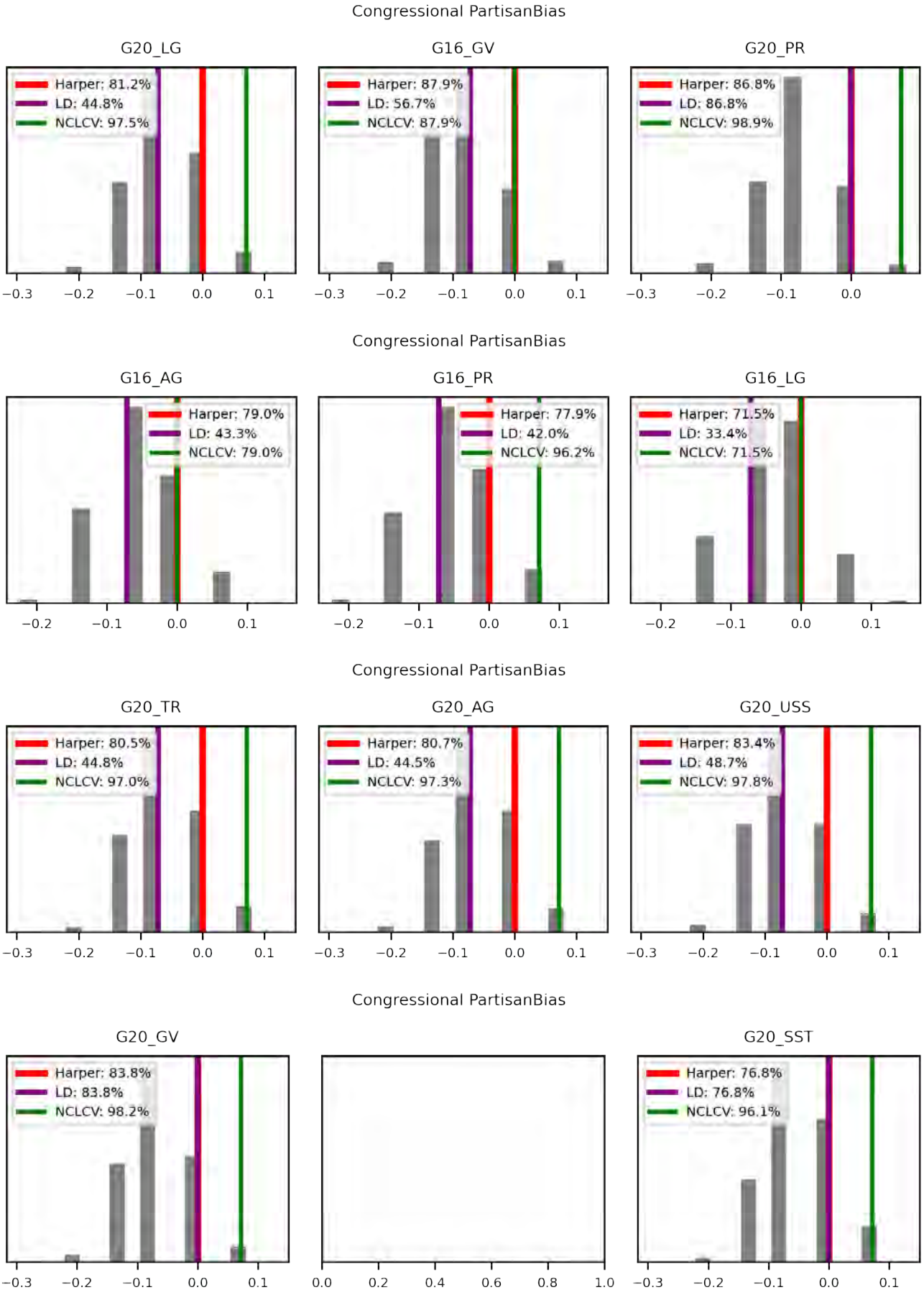

FIGURE 6. Histogram of partisan bias for all 11 elections. The numbers in the legend are the percentile in the ensemble for the corresponding plan.

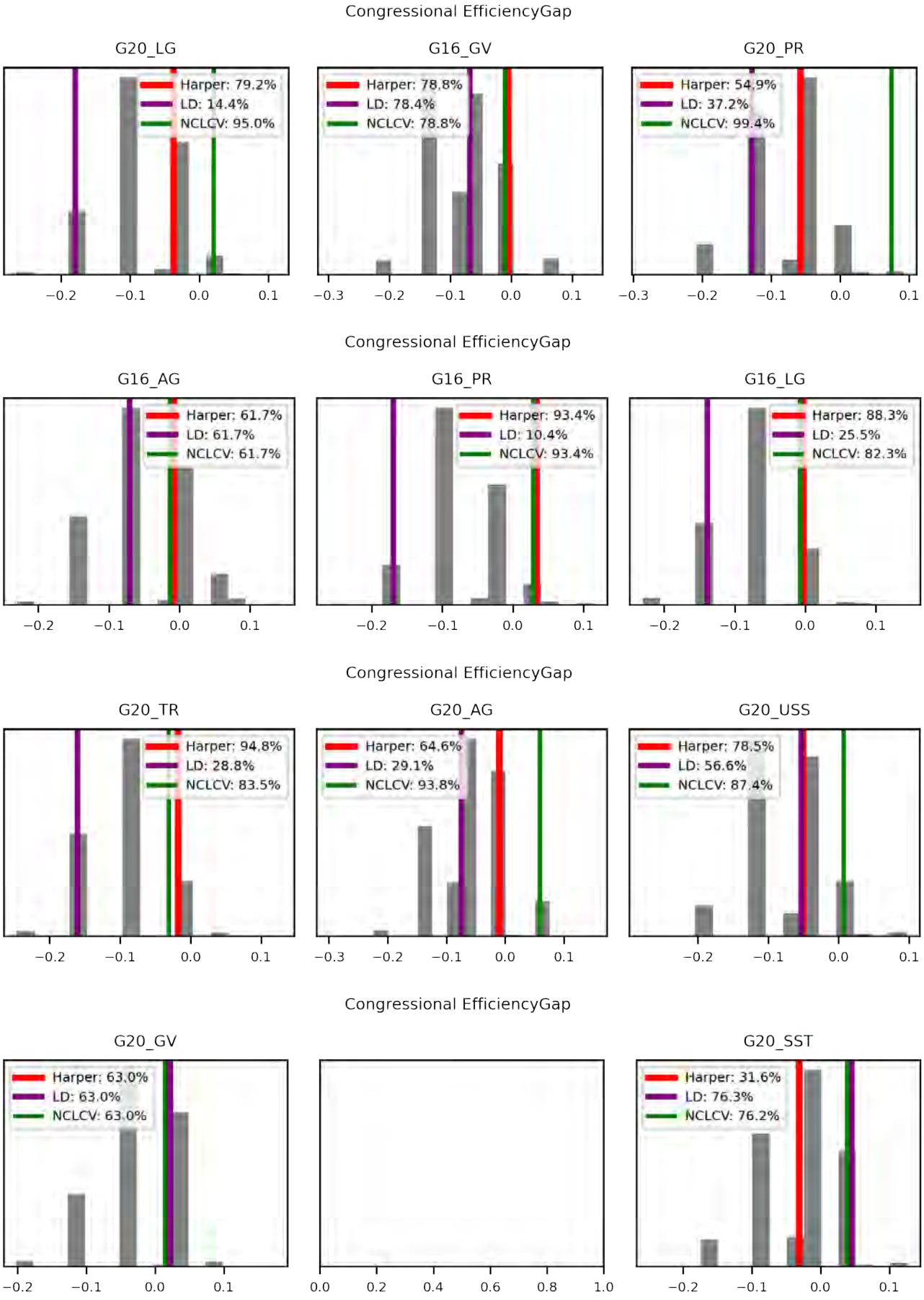

FIGURE 7. Histogram of congressional efficiency gap for all 11 elections. The percentages in the legend represent percentile of the corresponding score in the ensemble.

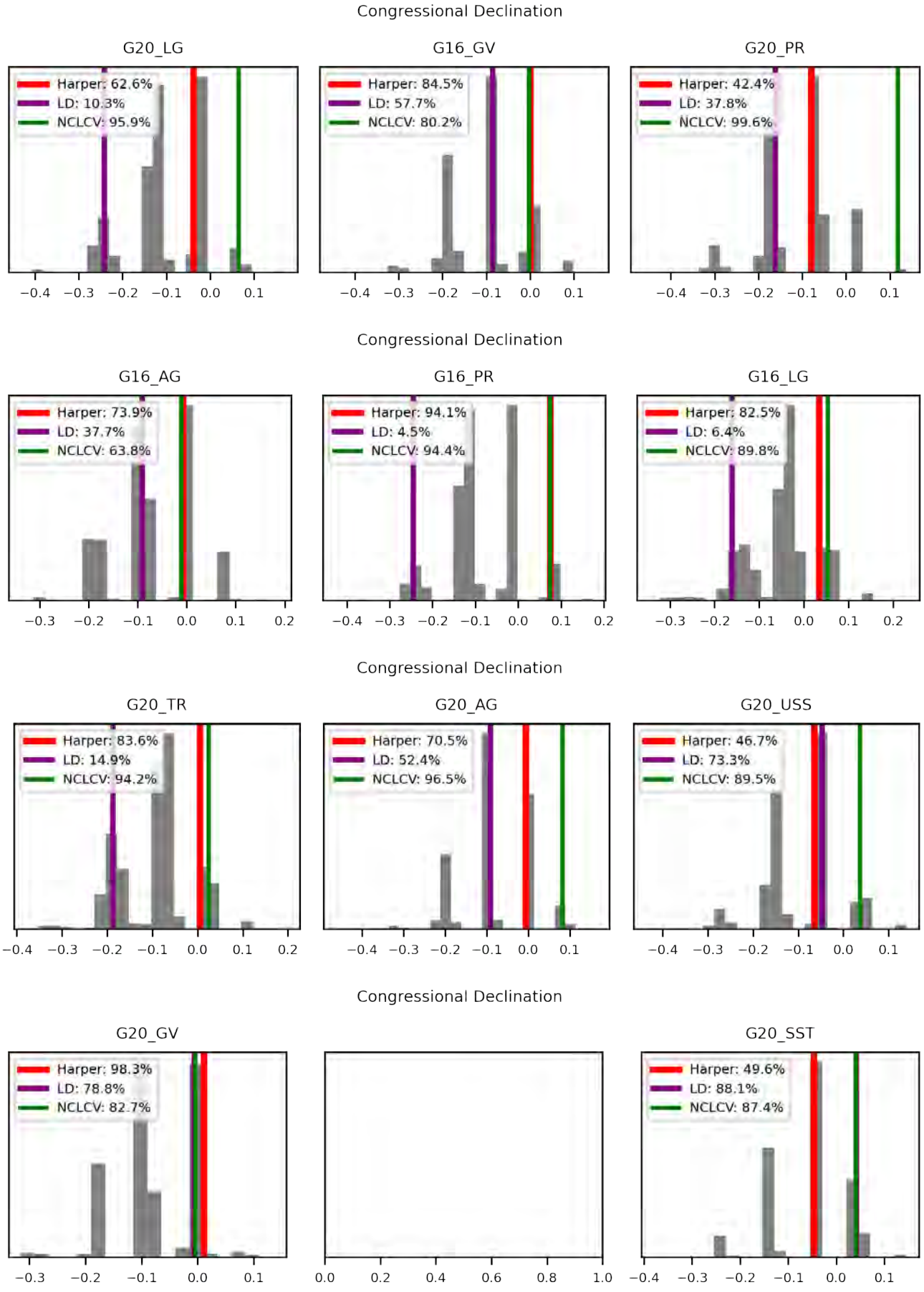

FIGURE 8. Histogram of congressional partisan declination for all 11 elections. The percentages in the legend represent percentile of the corresponding score in the ensemble.

Congressional Mean–Median

Proposed_Plan	Harper	LD	NCLCV	Enacted
G20PRE	−0.1	0.1	0.9	−6.4
G20USS	−0.5	−0.7	1.3	−5.7
G20GOV	0.0	−0.1	1.5	−5.7
G20LTG	0.1	−0.3	1.5	−6.2
G20ATG	−0.0	−0.3	1.7	−6.2
G20TRE	−0.3	−0.7	1.3	−5.5
G20SOS	−0.1	−0.3	2.2	−6.1
G16PRE	0.3	−1.3	1.1	−5.3
G16GOV	−1.0	−1.9	0.6	−4.1
G16LTG	−1.3	−2.7	−0.2	−4.4
G16ATG	−1.0	−2.2	0.1	−3.8
Average	−0.3	−0.9	1.1	−5.4

TABLE 1. Mean–median scores listed as percentages (times 100) for the proposed Congressional plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 5)—not as isolated numbers.

Congressional Partisan Bias

Proposed_Plan	Harper	LD	NCLCV	
G20PRE	0.0	0.0	7.1	−21.4
G20USS	0.0	−7.1	7.1	−21.4
G20GOV	0.0	0.0	7.1	−21.4
G20LTG	0.0	−7.1	7.1	−21.4
G20ATG	0.0	−7.1	7.1	−21.4
G20TRE	0.0	−7.1	7.1	−21.4
G20SOS	0.0	0.0	7.1	−21.4
G16PRE	0.0	−7.1	7.1	−21.4
G16GOV	0.0	−7.1	0.0	−21.4
G16LTG	0.0	−7.1	0.0	−21.4
G16ATG	0.0	−7.1	0.0	−21.4
Average	0.0	−5.2	5.2	−21.4

TABLE 2. Partisan bias scores listed as percentages (times 100) for the proposed Congressional plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 6)—not as isolated numbers.

Congressional Efficiency Gap

Proposed_Plan	Harper	LD	NCLCV	Enacted
G20PRE	−5.8	−12.8	7.5	−20.1
G20USS	−5.1	−5.3	0.7	−19.5
G20GOV	1.7	2.2	1.5	−26.0
G20LTG	−3.7	−17.9	2.1	−18.1
G20ATG	−1.1	−7.4	5.9	−21.6
G20TRE	−1.8	−16.0	−3.1	−16.2
G20SOS	−3.1	4.6	3.9	−17.4
G16PRE	3.3	−16.9	2.9	−17.2
G16GOV	−0.5	−6.8	−1.0	−21.0
G16LTG	−0.3	−13.9	−0.7	−14.1
G16ATG	−0.8	−7.1	−1.3	−21.3
Average	−1.6	−8.8	1.7	−19.3

TABLE 3. Efficiency gap scores listed as percentages (times 100) for the proposed Congressional plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 7)—not as isolated numbers.

Congressional Declination

Proposed_Plan	Harper	LD	NCLCV	Enacted
G20PRE	−8.0	−16.2	11.8	−32.0
G20USS	−6.4	−4.7	3.7	−29.7
G20GOV	1.1	−0.6	−0.4	−41.4
G20LTG	−3.9	−24.1	6.6	−27.7
G20ATG	−0.6	−9.1	8.3	−33.8
G20TRE	0.5	−18.7	2.4	−22.3
G20SOS	−4.7	4.2	4.1	−24.6
G16PRE	7.4	−24.5	7.5	−28.3
G16GOV	−0.0	−8.5	−0.3	−32.4
G16LTG	3.3	−16.1	5.3	−19.9
G16ATG	−0.8	−9.1	−1.1	−32.6
Average	−1.1	−11.6	4.4	−29.5

TABLE 4. Partisan declination scores listed as percentages (times 100) for the proposed Congressional plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 8)—not as isolated numbers.

3. Senate Plan Analysis

I received three proposed Senate plans (LD, Harper, and NCLCV) to evaluate. I used the same methods to evaluate these plans as I did for the Congressional plans, but with a different ensemble.

3.1. **Senate Ensembles.** For analyzing the senate plans I used Dr. Mattingly's ensemble [3]. It was generated with the same method as the Congressional plan. According to my reading of [4] the resulting plans comply with the county clustering rules of *Stephenson*, maintain a population balance that deviates by no more than 5%, They are also designed to produce contiguous districts that are relatively compact and to reduce the number of counties split. This ensemble does not explicitly preserve municipalities, except as a secondary consequence of other parameter settings. This is important because municipality splits are known to have a significant interaction with partisan vote shares and measures of partisan symmetry. According to [4] the distribution seems well mixed, but I cannot verify the mixing directly.

3.2. **Seats Won.** The histograms of seats won in Figure 9 show Harper and NCLCV both are mostly typical of the ensemble, while LD is often a significant outlier in favor of the Republicans.

3.3. **Rank-Ordered Violin Plots.** As with seats won the rank-ordered violin plots show Harper and NCLCV are both mostly typical of the ensemble, while LD is often deviates in favor of the Republicans; see Figure 10.

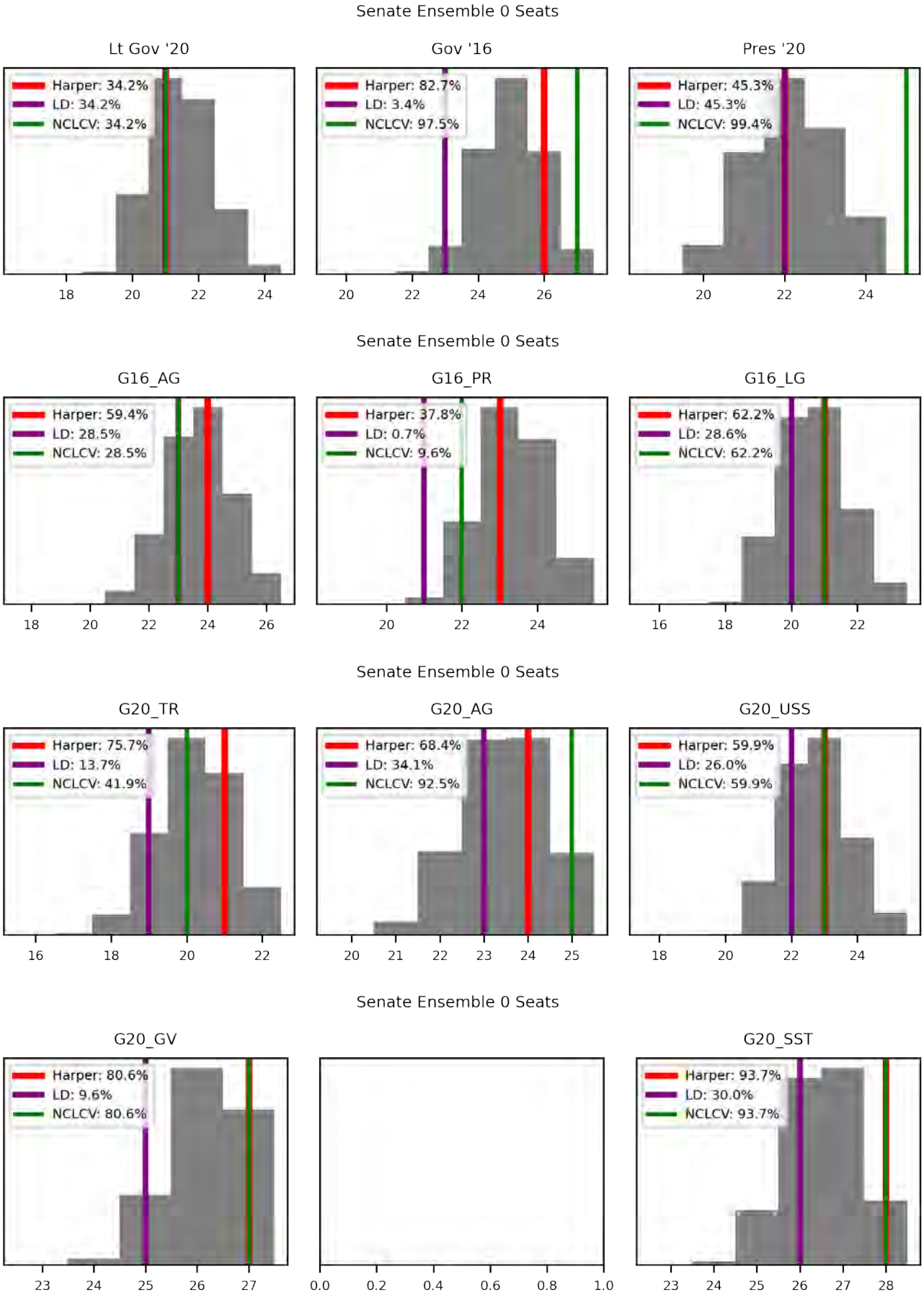

FIGURE 9. Histograms of congressional seats won in all 11 elections for the ensemble plans. The percentages in the legend represent percentile of the corresponding score in the ensemble.

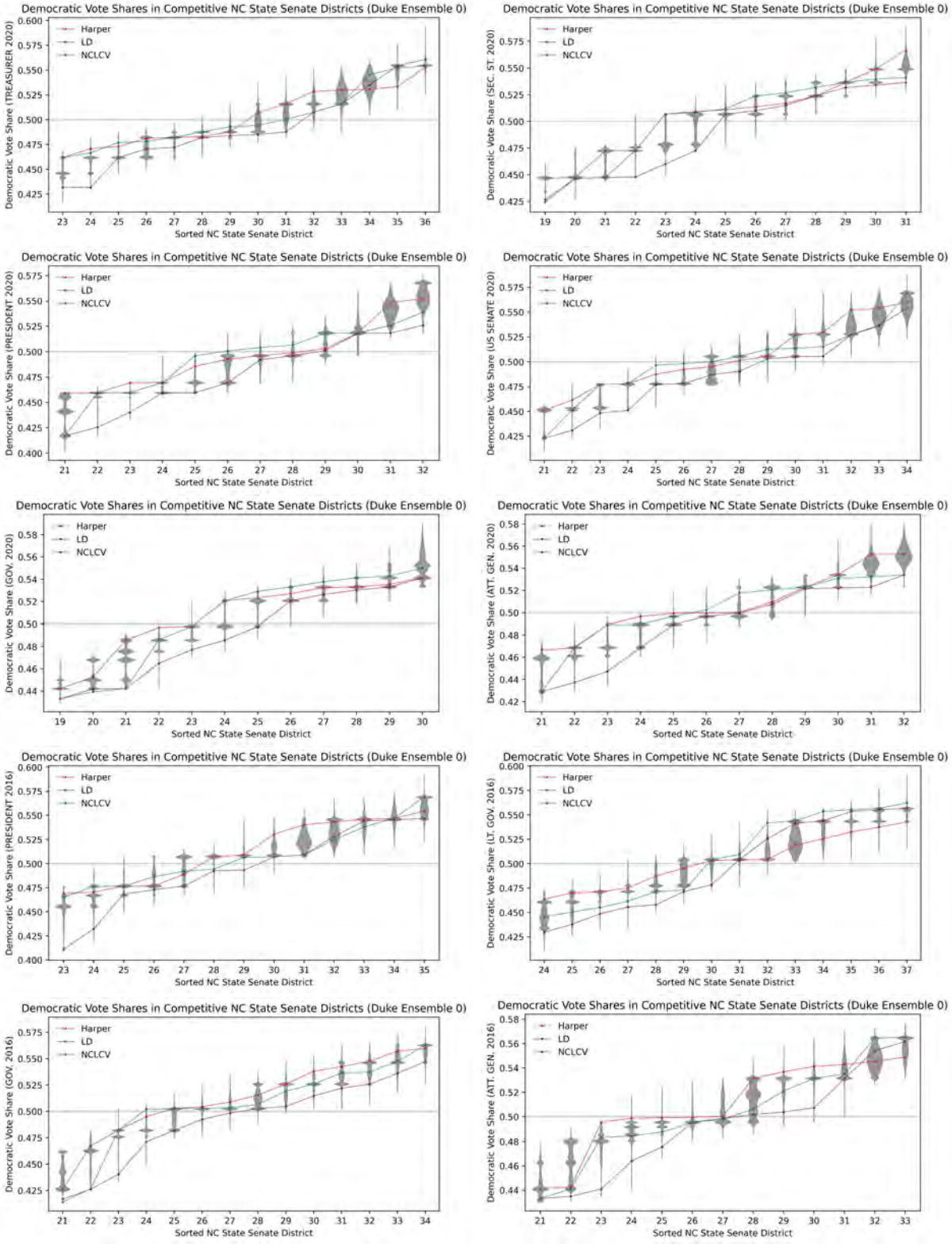

FIGURE 10. Rank-ordered senate districts for 10 of the elections (all elections but G20LG). These plots show only the most competitive districts.

3.4. **Other Metrics.**

3.4.1. *Mean–Median.* Table 5 shows my calculations of the mean–median scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

As shown in Figure 11 the mean–median score identifies the LD plan as a Republican-favoring outlier (lower than the 5th percentile) for three of the 11 elections (G20PR, G16AG, and G16LG).

The NCLCV plan is a pro-Democratic outlier (greater than 95th percentile) in four of the elections (G20PR, G20LG, G20USS, and G20GV).

The Harper plan leans toward the Democratic side of the distribution, but is not an outlier.

3.4.2. *Partisan Bias.* Table 6 shows my calculations of the partisan bias scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

As shown in Figure 12, the LD plan is a Republican-favoring outlier twice, and the Harper plan is a pro-Democratic outlier once. But the NCLCV plan stands out as a pro-Democratic outlier for partisan bias in four elections (G20PR, G20TR, G20USS, and G20GV).

3.4.3. *Efficiency Gap.* Table 7 shows my calculations of the efficiency gap scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

In Figure 13 the efficiency gap flag the NCLCV plan as a pro-Democratic outlier five times, and four of those are significant (99th percentile or greater). Harper shows up twice as Democratic outlier and LD shows up twice as a Republican outlier.

3.4.4. *Declination.* Table 8 shows my calculations of the declination scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

As shown in Figure 14 the declination marks the LD plan as a Republican outlier (below 5%) three times. The NCLCV plan shows as a Democratic outlier (over 95%) three times and Harper twice (G20GV and G20SST).

3.5. **Senate Conclusion.** The partisan symmetry scores give weak evidence of of partisan gerrymandering in the LD plan, and the seat margins in the rank-ordered violin plots give strong evidence of partisan gerrymandering in the LD plan.

The seat margins in the rank-ordered violin plots give some evidence of partisan gerrymandering in the NCLCV plan, and that is corroborated by the many outliers among the partisan symmetry scores.

These conclusions do not take VRA racial considerations into account.

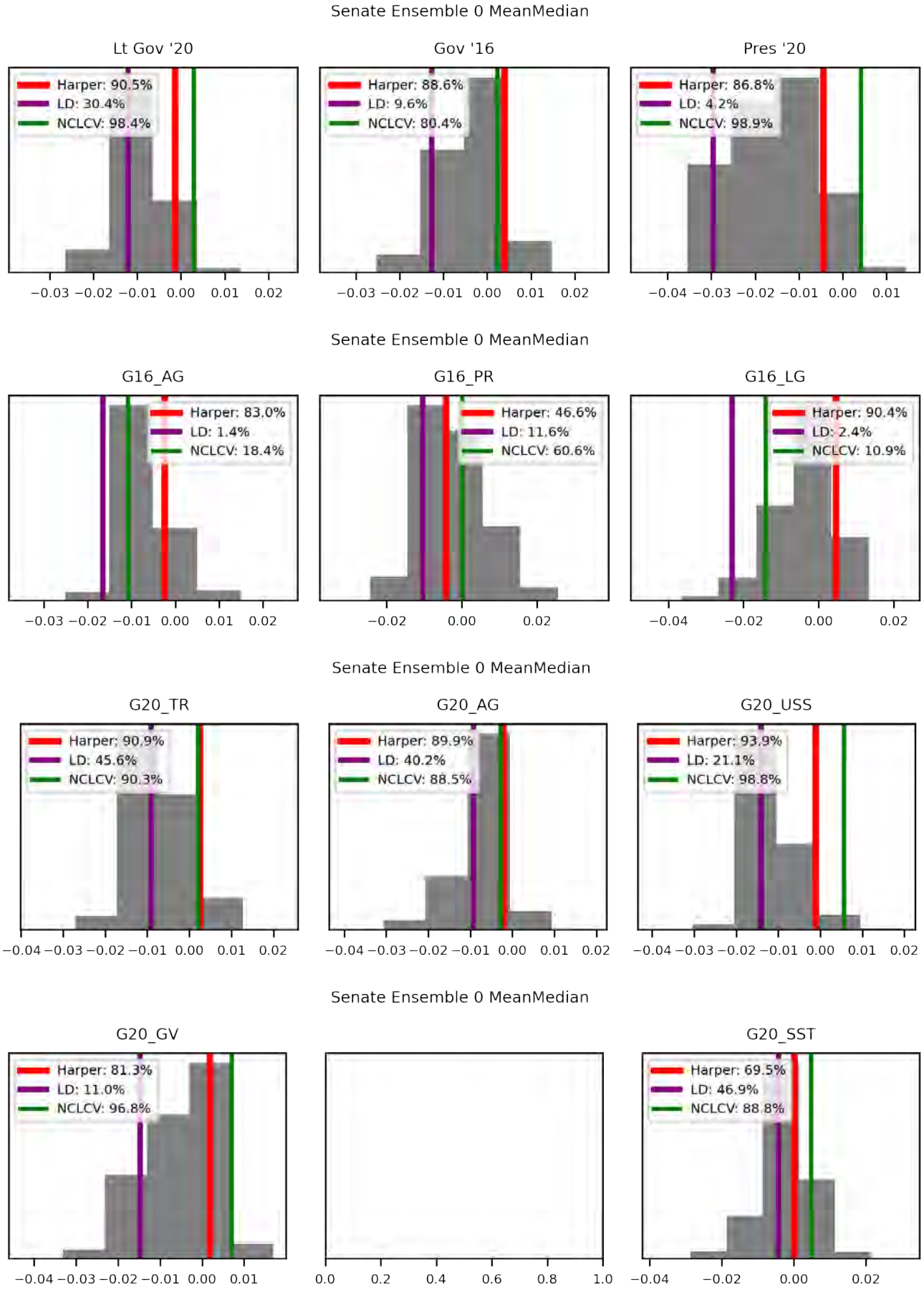

FIGURE 11. Histogram of senate ensemble mean–median score for all 11 elections.

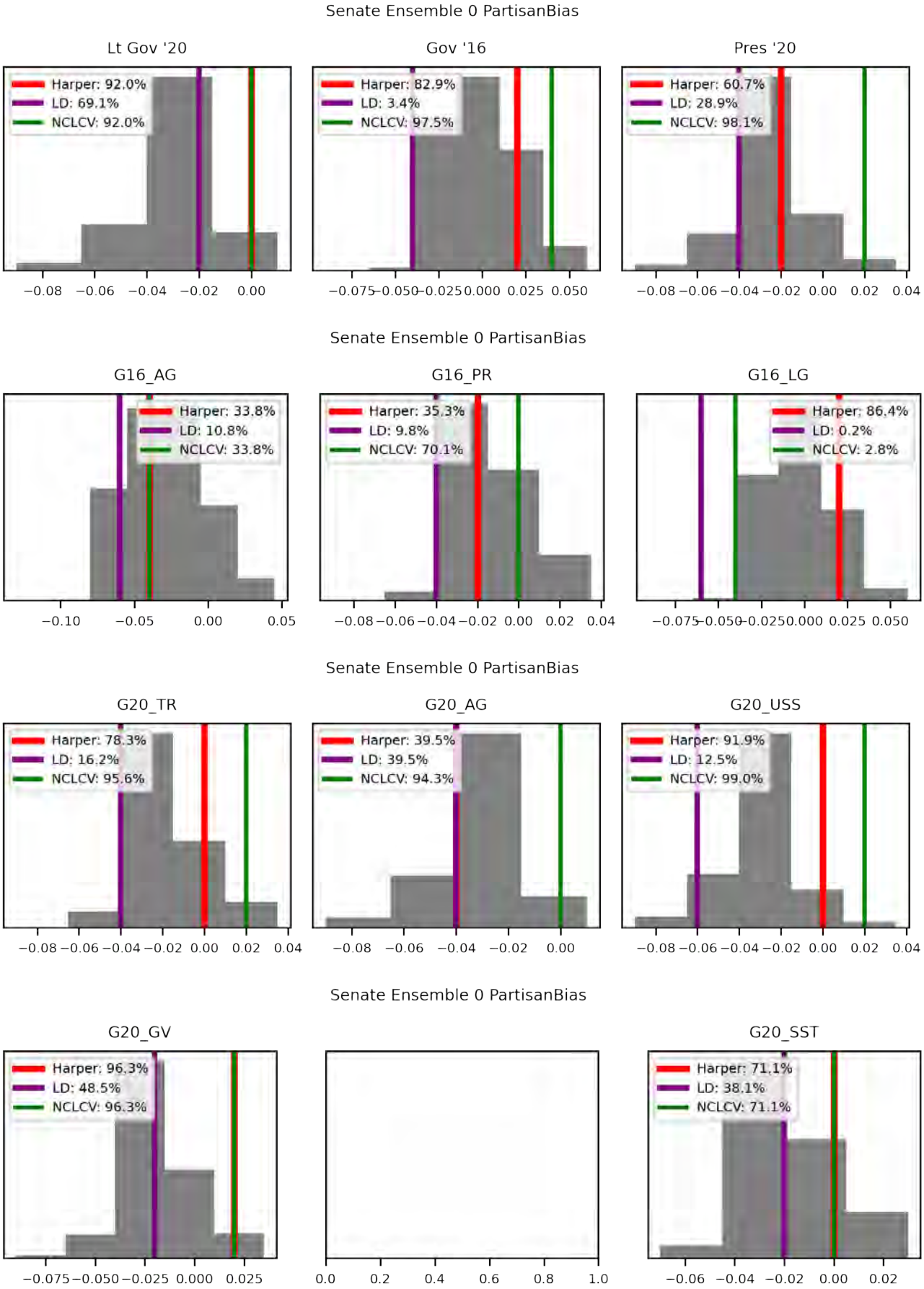

FIGURE 12. Histogram of partisan bias for all 11 elections.

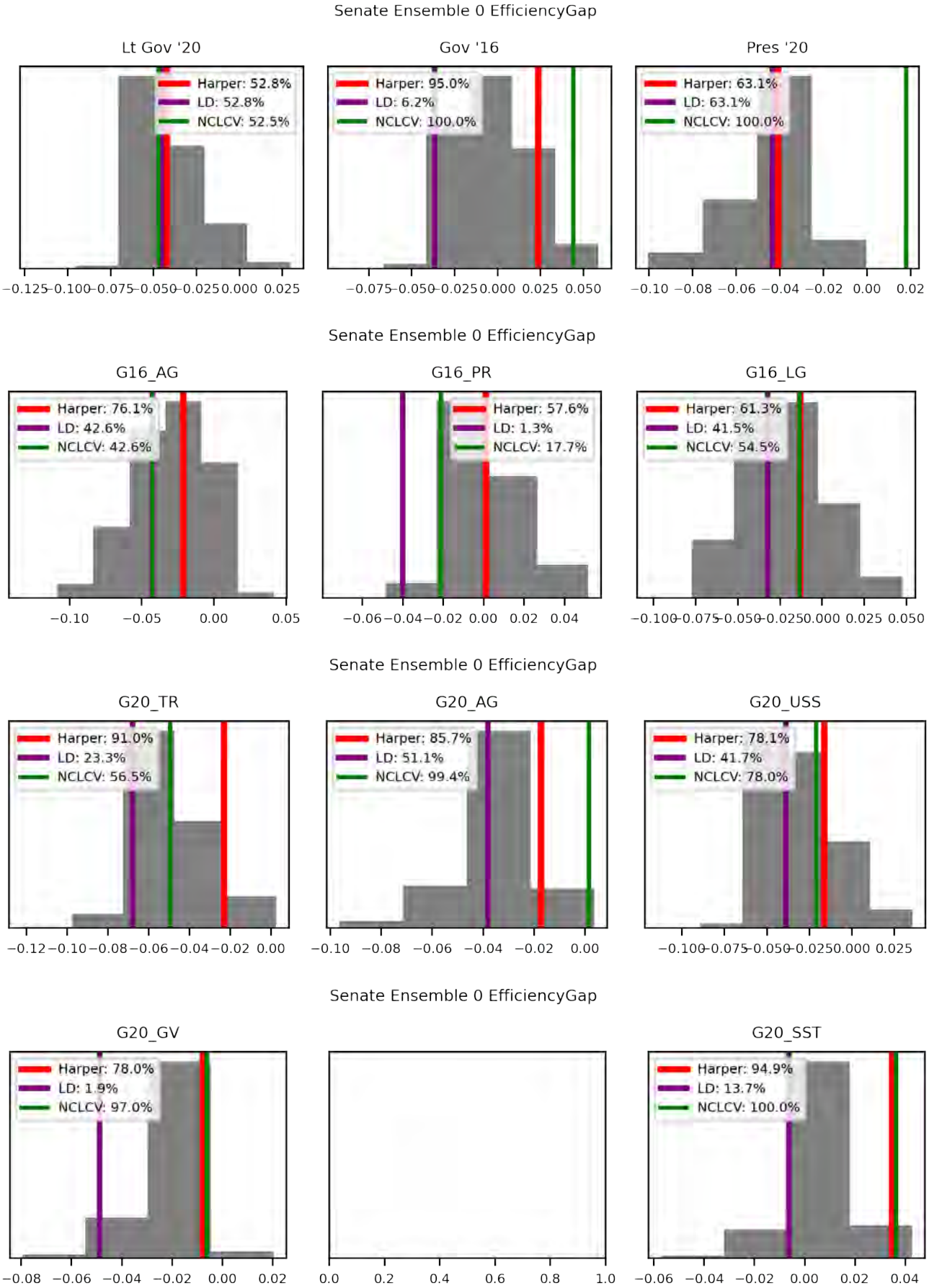

FIGURE 13. Histogram of senate ensemble efficiency gap for all 11 elections. The percentages in the legend represent percentile of the corresponding score in the ensemble.

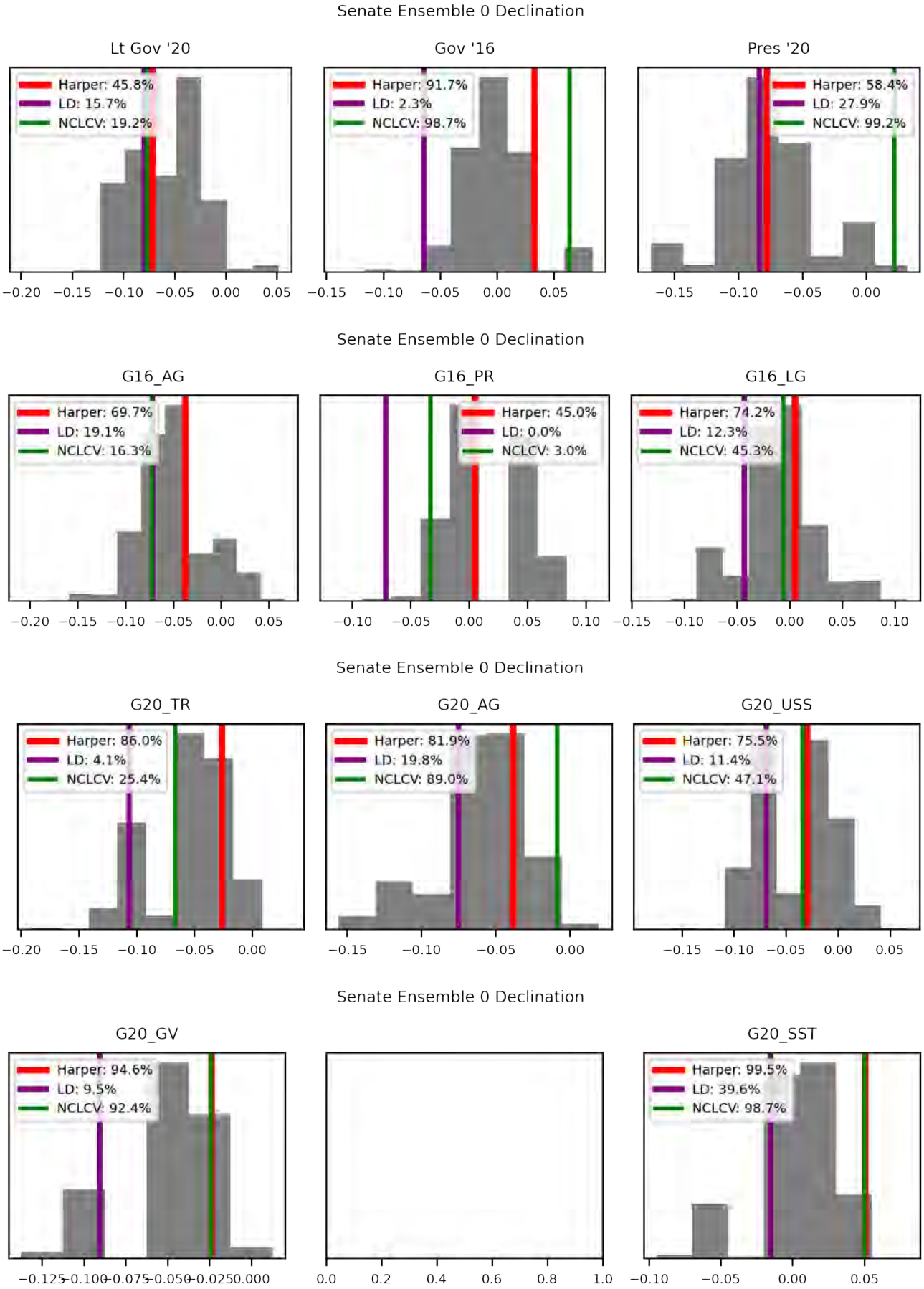

FIGURE 14. Histogram of senate ensemble partisan declination for all 11 elections. The percentages in the legend represent percentile of the corresponding score in the ensemble.

Senate Mean–Median

Proposed_Plan	Harper	LD	NCLCV	Enacted
G20PRE	−0.4	−3.0	0.4	−3.8
G20USS	−0.1	−1.4	0.6	−4.0
G20GOV	0.2	−1.5	0.7	−4.5
G20LTG	−0.1	−1.2	0.3	−3.7
G20ATG	−0.2	−0.9	−0.3	−3.9
G20TRE	0.2	−0.9	0.2	−3.3
G20SOS	0.0	−0.4	0.5	−3.7
G16PRE	−0.4	−1.0	0.0	−2.0
G16GOV	0.4	−1.3	0.2	−3.1
G16LTG	0.5	−2.3	−1.4	−4.1
G16ATG	−0.3	−1.7	−1.1	−3.2
Average	−0.0	−1.4	0.0	−3.6

TABLE 5. Mean–median scores listed as percentages (times 100) for the proposed Senate plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 11)—not as isolated numbers.

Senate Partisan Bias

Proposed_Plan	Harper	LD	NCLCV	Enacted
G20PRE	−2.0	−4.0	2.0	−8.0
G20USS	0.0	−6.0	2.0	−8.0
G20GOV	2.0	−2.0	2.0	−6.0
G20LTG	0.0	−2.0	0.0	−8.0
G20ATG	−4.0	−4.0	0.0	−8.0
G20TRE	0.0	−4.0	2.0	−10.0
G20SOS	0.0	−2.0	0.0	−6.0
G16PRE	−2.0	−4.0	0.0	−10.0
G16GOV	2.0	−4.0	4.0	−10.0
G16LTG	2.0	−6.0	−4.0	−8.0
G16ATG	−4.0	−6.0	−4.0	−10.0
Average	−0.5	−4.0	0.4	−8.4

TABLE 6. Partisan bias scores listed as percentages (times 100) for the proposed Senate plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 12)—not as isolated numbers.

Proposed_Plan	Harper	LD	NCLCV	Enacted
G20PRE	−4.1	−4.3	1.8	−8.5
G20USS	−1.6	−3.9	−2.1	−8.0
G20GOV	−0.8	−4.9	−0.6	−8.8
G20LTG	−4.2	−4.5	−4.7	−10.9
G20ATG	−1.7	−3.8	0.2	−8.0
G20TRE	−2.3	−6.8	−4.9	−11.2
G20SOS	3.5	−0.6	3.7	−4.6
G16PRE	0.1	−4.0	−2.1	−8.5
G16GOV	2.4	−3.6	4.4	−10.2
G16LTG	−1.3	−3.2	−1.3	−5.5
G16ATG	−2.1	−4.2	−4.2	−10.5
Average	−1.1	−4.0	−0.9	−8.6

TABLE 7. Efficiency gap scores listed as percentages (times 100) for the proposed Senate plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 13)—not as isolated numbers.

Senate Declination

Proposed_Plan	Harper	LD	NCLCV	Enacted
G20PRE	−7.8	−8.4	2.2	−16.9
G20USS	−3.0	−6.9	−3.4	−15.3
G20GOV	−2.4	−9.1	−2.4	−16.2
G20LTG	−7.2	−8.0	−7.7	−20.9
G20ATG	−3.8	−7.5	−0.9	−15.3
G20TRE	−2.7	−10.6	−6.7	−20.5
G20SOS	5.1	−1.5	5.0	−8.5
G16PRE	0.5	−7.1	−3.3	−16.2
G16GOV	3.3	−6.4	6.4	−17.9
G16LTG	0.5	−4.3	−0.6	−10.0
G16ATG	−3.8	−7.2	−7.2	−18.4
Average	−1.9	−7.0	−1.7	−16.0

TABLE 8. Declination scores listed as percentages (times 100) for the proposed Senate plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 14)—not as isolated numbers.

4. House Plan Analysis

I followed the same procedures for analyzing the House plans as I did for the Senate and Congressional plans, but here I had only two plans (LD and NCLCV). I used the ensemble [**?**], whose characteristics are similar to those of the Senate ensemble used above.

4.1. **Seats Won.** Considering the number of seats won in each election, as shown in Figure 15, Both the LD and NCLCV plans appear to be mostly typical in terms of the number of seats won, except in G20PR and G16LG where NCLCV is much higher (pro Democrat) than the main distribution.

4.2. **Rank-Ordered Violin Plots.** Referring to Figure 16, which focuses only on the most competitive districts, the NCLCV plan appears to deviate much more from the ensemble than the LD plan does.

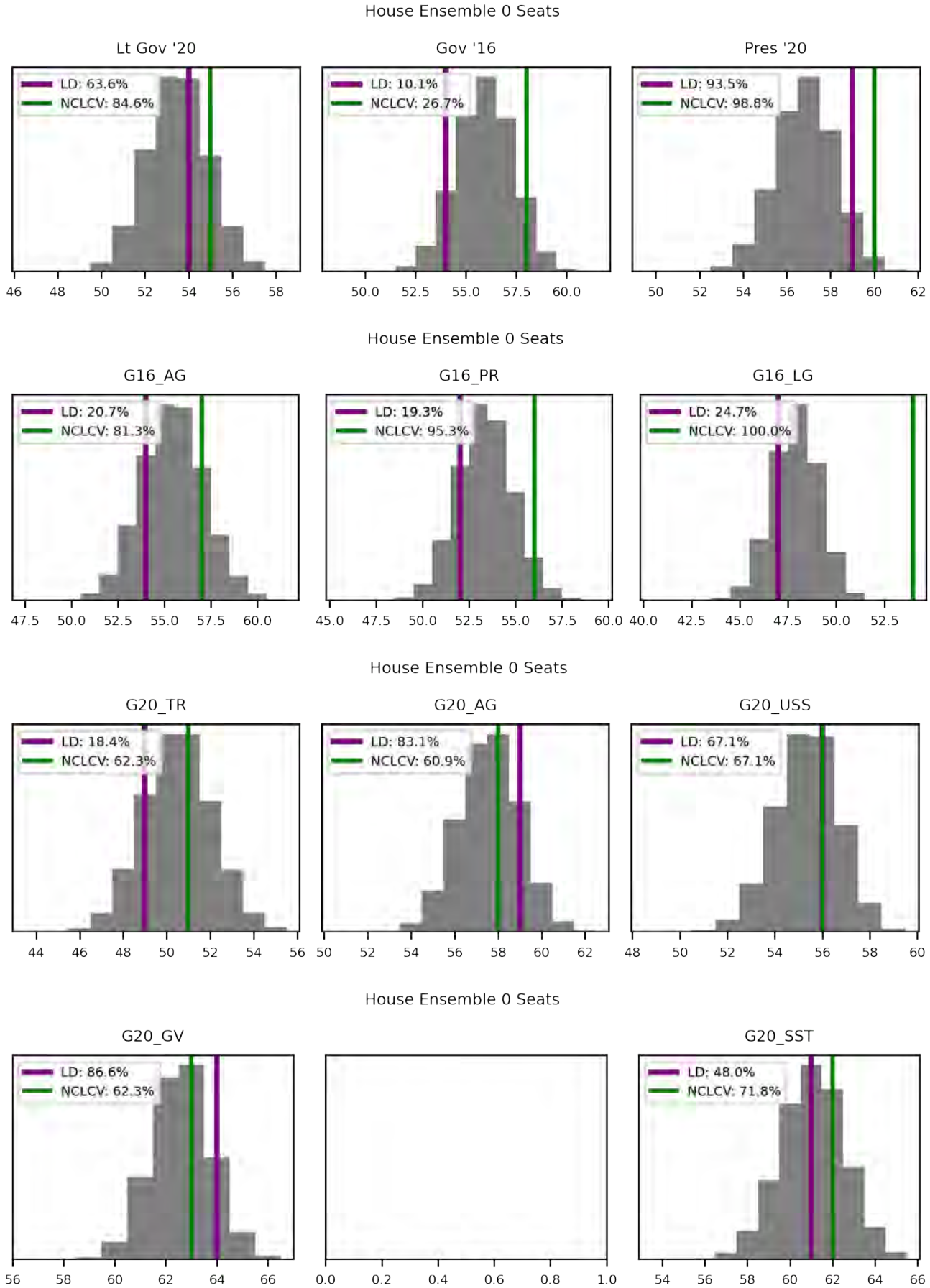

FIGURE 15. Histograms of congressional seats won in all 11 elections for Ensemble 0 plans. The percentages in the legend represent percentile of the corresponding score in the ensemble.

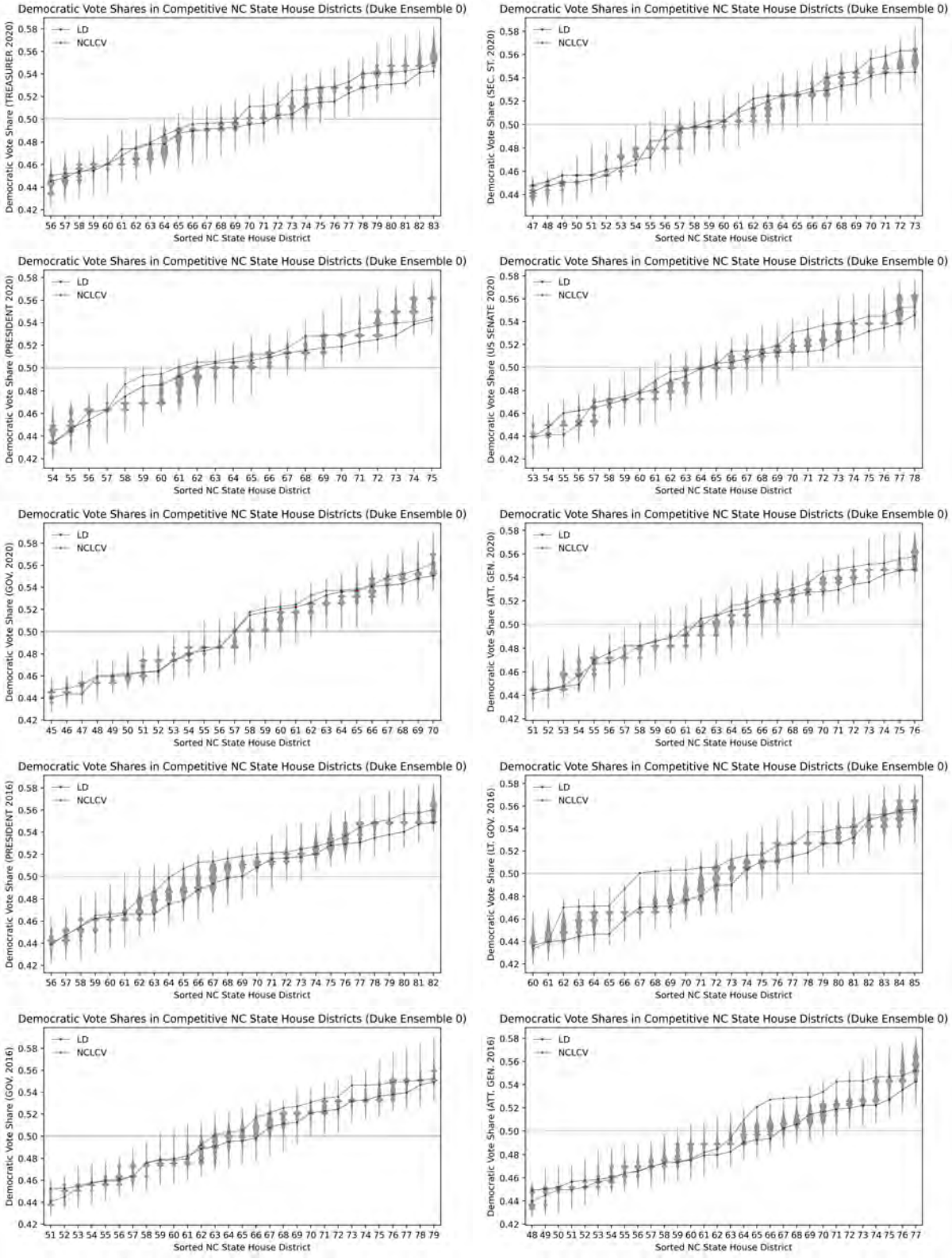

FIGURE 16. Rank-ordered house districts for 10 of the elections (all elections but G20LG) using Ensemble 0. These plots show only the most competitive districts.

4.3. **Other Metrics.**

4.3.1. *Mean–Median.* Table 9 shows my calculations of the mean–median scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 17)—not as isolated numbers.

The distribution is shifted in the negative direction, so scores very close to 0 look more like outliers than large negative scores. Specifically, the NCLCV score of 0.1% in the election G20PR is very close to zero, but it is more Democratic favoring than 98% of all plans, so this plan is an outlier for this distribution, while the LD plan's score of −0.7% is more typical of the distribution.

Although there are occasional outliers, taken as a whole, neither proposed plan looks to me like a partisan gerrymander with respect to the distribution of mean–median scores.

4.3.2. *Partisan Bias.* Table 10 shows my calculations of the partisan bias scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 18)—not as isolated numbers.

Although there are occasional outliers, taken as a whole, neither proposed plan looks to me like a partisan gerrymander with respect to the distribution of partisan bias scores.

4.3.3. *Efficiency Gap.* Table 11 shows my calculations of the efficiency gap scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 19)—not as isolated numbers.

Although there are occasional outliers, taken as a whole, neither proposed plan looks to me like a partisan gerrymander with respect to the distribution of efficiency gap scores.

4.3.4. *Declination.* Table 4 shows my calculations of the declination scores of the three plans in the different races. These scores should be interpreted in light of the full distribution of scores (histograms in Figure 20)—not as isolated numbers.

Although there are occasional outliers, taken as a whole, neither proposed plan looks to me like a partisan gerrymander with respect to the distribution of declination scores.

4.4. **House Conclusion.** The seat margins shown in the rank-ordered violin plots of Figure 16 give evidence of partisan gerrymandering in the NCLCV plan.

These conclusions do not take VRA racial considerations into account.

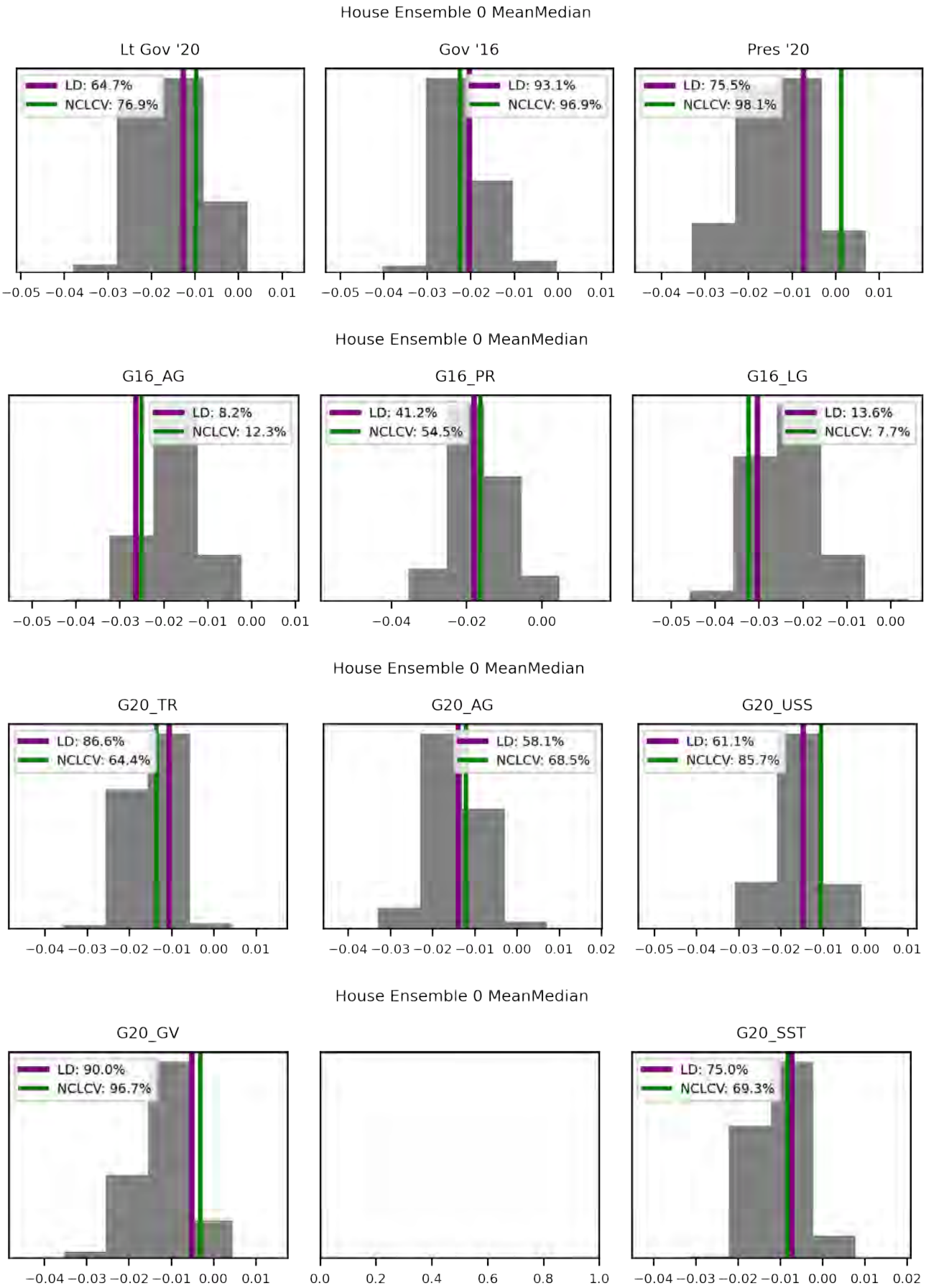

FIGURE 17. Histogram of house ensemble 0 mean–median score for all 11 elections.

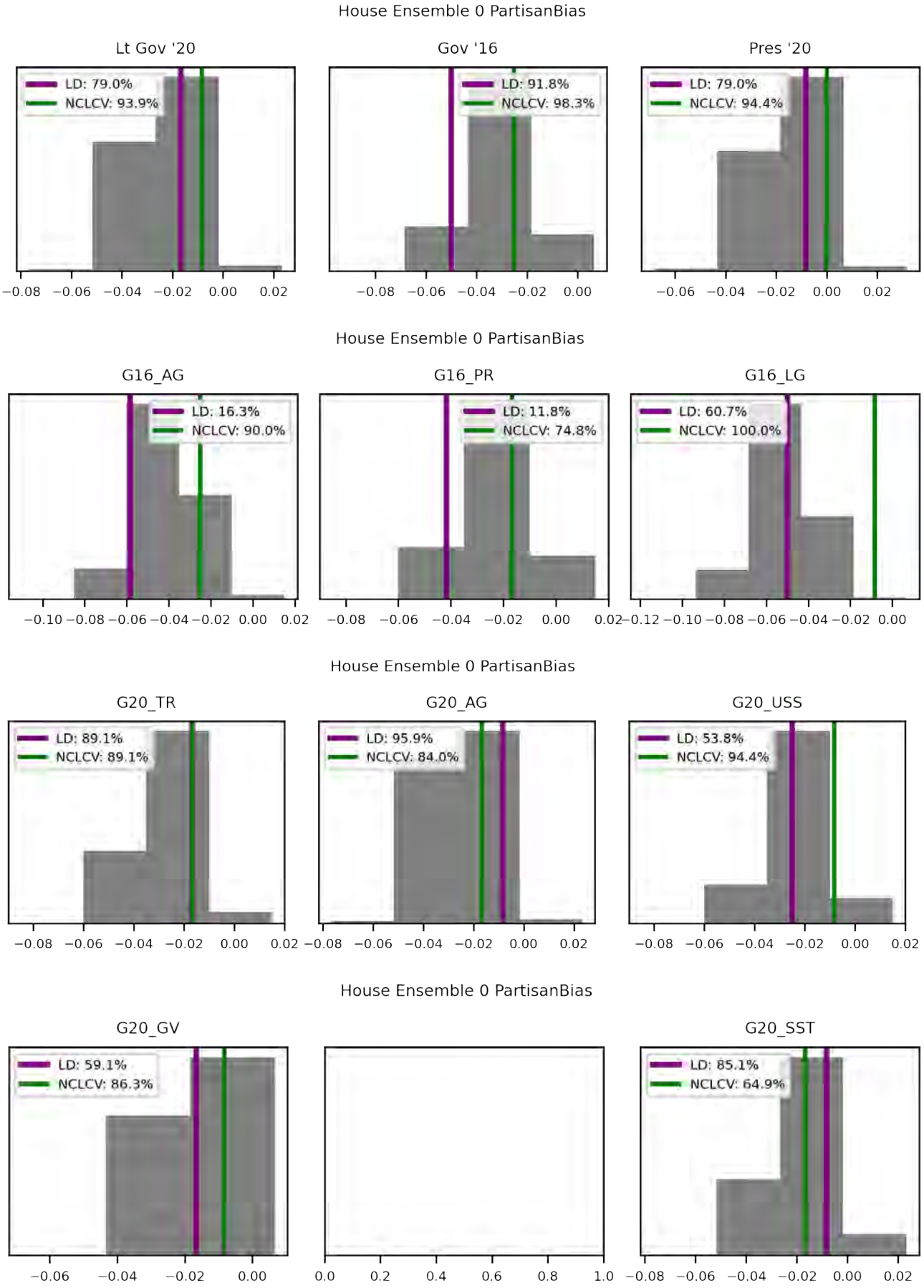

FIGURE 18. Histogram of partisan bias for all 11 elections for Ensemble 0.

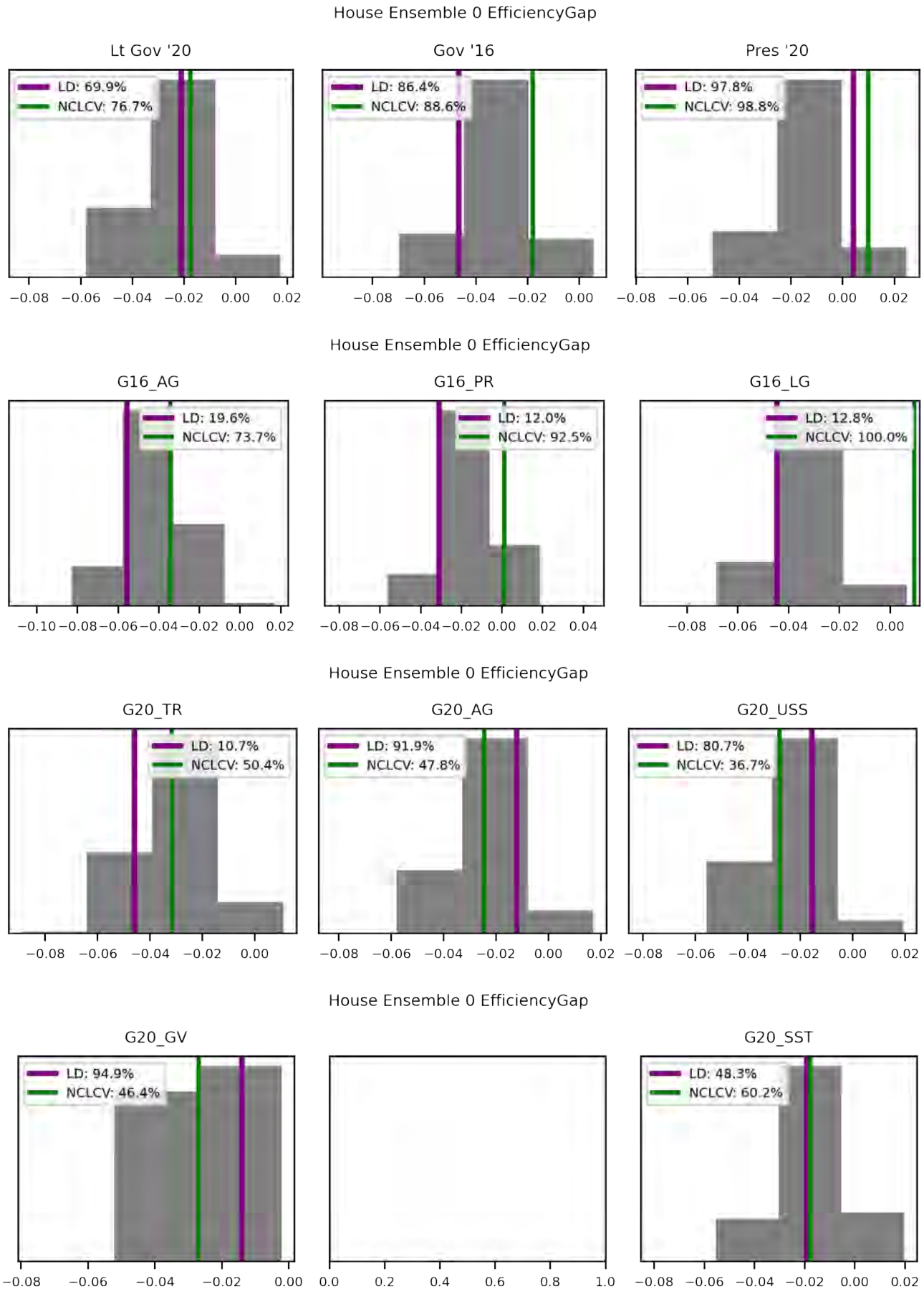

FIGURE 19. Histogram of house ensemble 0 efficiency gap for all 11 elections.

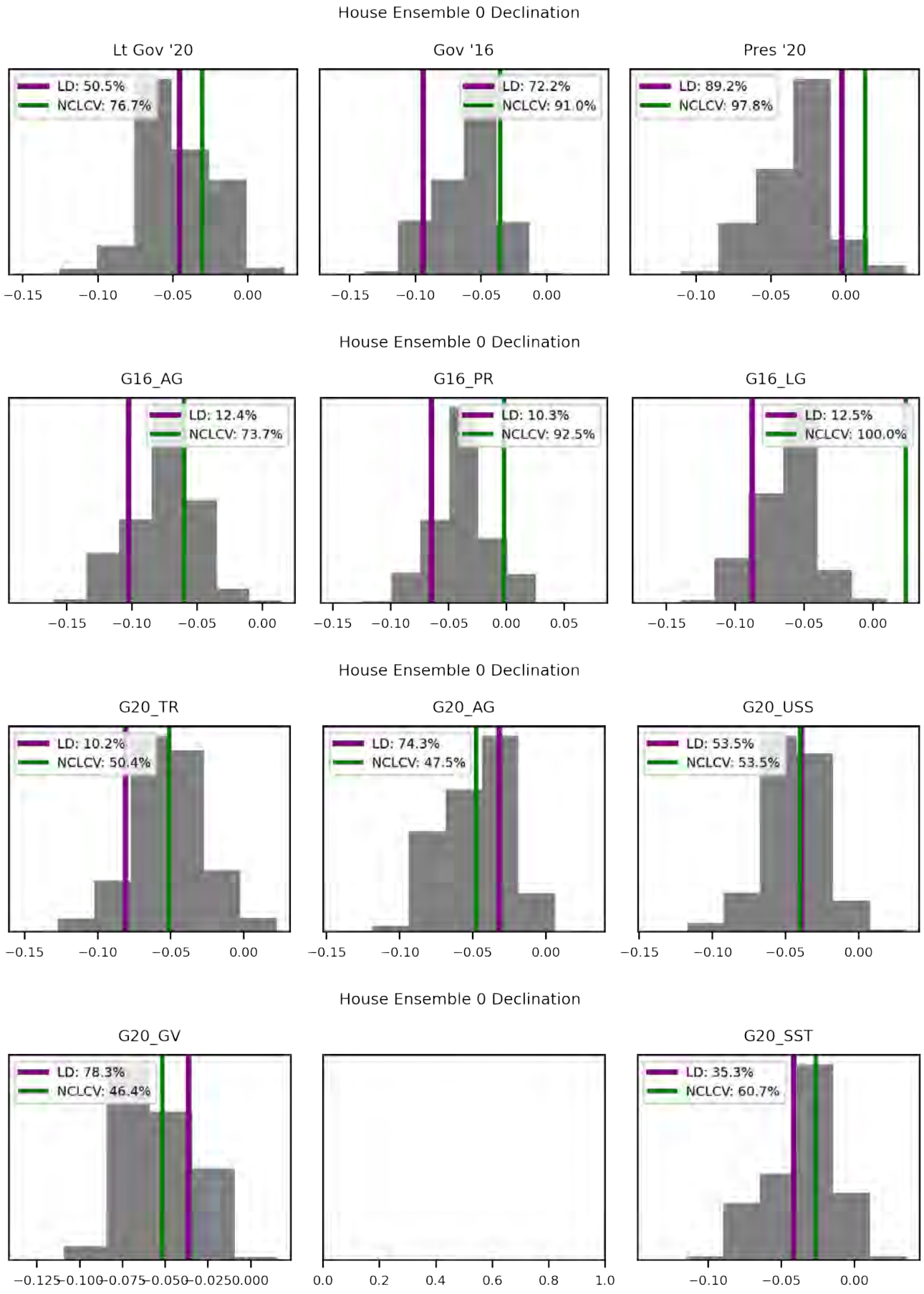

FIGURE 20. Histogram of house ensemble 0 partisan declination for all 11 elections.

House Mean–Median

Proposed_Plan	LD	NCLCV	Enacted
G20PRE	−0.7	0.1	−3.0
G20USS	−1.5	−1.0	−3.4
G20GOV	−0.5	−0.3	−3.3
G20LTG	−1.3	−1.0	−3.4
G20ATG	−1.4	−1.2	−3.1
G20TRE	−1.1	−1.4	−3.4
G20SOS	−0.7	−0.8	−3.1
G16PRE	−1.8	−1.6	−5.1
G16GOV	−2.0	−2.2	−4.1
G16LTG	−3.0	−3.2	−4.4
G16ATG	−2.6	−2.5	−4.5
Average	−1.5	−1.4	−3.7

TABLE 9. Mean–median scores listed as percentages (times 100) for the proposed House plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

House Partisan Bias

Proposed_Plan	LD	NCLCV	Enacted
G20PRE	−0.8	0.0	−6.7
G20USS	−2.5	−0.8	−7.5
G20GOV	−1.7	−0.8	−8.3
G20LTG	−1.7	−0.8	−7.5
G20ATG	−0.8	−1.7	−7.5
G20TRE	−1.7	−1.7	−7.5
G20SOS	−0.8	−1.7	−7.5
G16PRE	−4.2	−1.7	−9.2
G16GOV	−5.0	−2.5	−8.3
G16LTG	−5.0	−0.8	−8.3
G16ATG	−5.8	−2.5	−9.2
Average	−2.7	−1.4	−8.0

TABLE 10. Partisan bias scores listed as percentages (times 100) for the proposed House plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

House Efficiency Gap

Proposed_Plan	LD	NCLCV	Enacted
G20PRE	0.4	1.0	−7.5
G20USS	−1.5	−2.8	−8.7
G20GOV	−1.4	−2.7	−6.3
G20LTG	−2.1	−1.8	−8.9
G20ATG	−1.2	−2.4	−8.6
G20TRE	−4.6	−3.2	−8.0
G20SOS	−1.9	−1.8	−8.9
G16PRE	−3.1	0.1	−5.2
G16GOV	−4.7	−1.8	−8.2
G16LTG	−4.4	1.0	−7.0
G16ATG	−5.5	−3.4	−9.0
Hou EG mean	−2.7	−1.6	−7.8

TABLE 11. Efficiency gap scores listed as percentages (times 100) for the proposed House plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

House Declination

Proposed_Plan	LD	NCLCV	Enacted
G20PRE	−0.3	1.3	−14.9
G20USS	−3.9	−4.0	−16.8
G20GOV	−3.6	−5.1	−12.7
G20LTG	−4.5	−3.0	−18.0
G20ATG	−3.2	−4.7	−15.7
G20TRE	−8.1	−5.1	−15.2
G20SOS	−4.1	−2.6	−16.3
G16PRE	−6.5	−0.2	−11.8
G16GOV	−9.4	−3.5	−15.7
G16LTG	−8.7	2.4	−14.4
G16ATG	−10.2	−6.0	−16.4
Average	−5.7	−2.8	−15.3

TABLE 12. Declination scores listed as percentages (times 100) for the proposed House plans across the 11 elections. These scores should be interpreted in light of the full distribution of scores (histograms)—not as isolated numbers.

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[6] Gregory S. Warrington. A comparison of partisan-gerrymandering measures. *Election Law Journal: Rules, Politics, and Policy*, 18(3):262–281, 2019.

Evaluation of Remedial Plans
Prof. Sam Wang, Princeton University
February 21, 2022

Summary: This report evaluates the likely performance and partisan fairness of remedial plans for North Carolina Congressional, state Senate, and state House maps in the cases of *Harper v. Hall* and *NCLCV v. Hall*. Remedial plans were submitted by the North Carolina General Assembly ("Legislative Defendants"). Harper plaintiffs offered two remedial maps, Congressional and state Senate. The NCLCV plaintiffs also offered a set of three remedial maps. This report finds that all three of the Legislative Defendants' plans favor Republicans in six metrics evaluated: seat partisan asymmetry, mean-median difference, partisan bias, lopsided wins, declination angle, and efficiency gap. The seat partisan asymmetry in 1.7 seats in the Congressional plan, 2.1 seats in the Senate plan, and 7.2 seats in the House plan. The Harper plaintiffs' plans show mixed or no advantage for either party. The NCLCV plaintiffs' plans show a Democratic advantage for the Congressional plan, mixed or no advantage for the Senate plan, and a Republican advantage for the House plan. In no case did the Legislative Defendants' remedial map come closer to partisan symmetry than the plaintiffs' alternative(s).

About Prof. Wang: Sam Wang is a professor at Princeton University, appointed in neuroscience with affiliation with the Program in Law and Public Affairs. He directs the Electoral Innovation Lab, a policy and research group which uses statistics, science, and law to analyze election systems, and in which capacity he soversee the Princeton Gerrymandering Project (gerrymander.princeton.edu), which provides non-partisan analysis of redistricting plans and reforms. He has published extensively on the subject of redistricting. In particular, he has written in the Stanford Law Review and the Election Law Journal on the subject of practical tests for detecting partisan gerrymandering. In these articles he has analyzed the mean-median difference and introduced a new measure, the lopsided-wins test. These measures fall into a broad category of tests of partisan symmetry, a topic on which he has been cited in two U.S. Supreme Court decisions.

I. INTRODUCTION

This report analyzes the remedial plans offered by parties in the North Carolina redistricting cases *Harper v. Hall* and *NCLCV v. Hall*. Those cases found that North Carolina's new Congressional, state House, and state Senate redistricting plans were illegal partisan gerrymanders in violation of the state constitution. The state Supreme Court has instructed the General Assembly to provide remedial maps for all three plans. The General Assembly provided these remedial maps on Friday, February 18, 2022, two passed on a partisan vote (Congressional and Senate) and one passed on a bipartisan vote (House). At that time the NCLCV plaintiffs also offered a set of three remedial maps. Harper plaintiffs offered two remedial maps, Congressional and state Senate.

I have analyzed these plans to determine their likely partisan performance. I apply statistical measures of partisan fairness to determine the amount of partisan favor that these maps show to either Republicans or Democrats.

Before applying the many tests for partisan fairness, I will briefly review the rationale and interpretations of the various tests.

II. MEASURING PARTISAN FAIRNESS

The broad majority of metrics used by the court to evaluate partisan fairness address the question of whether voters, counted in total within the state, are represented fairly given a particular arrangement of Congressional or legislative districts. These metrics are calculated based on voter behavior in recent elections. Some of the metrics allow a variety of likely future scenarios to be explored empirically.

Because the relationship between voting and representation is complex, it is useful to evaluate multiple metrics. The use of multiple metrics helps guard against the possibility that a particular metric may vary by chance. The use of multiple metrics also guards against the possibility that redistricters might cater to one specific metric, to create the appearance of compliance while maintaining a hidden partisan advantage. I will therefore consider a variety of metrics together, in their totality.

A. Partisan seat asymmetry

An important concept is whether the two parties would have commensurate outcomes if their vote shares were exchanged. The general concept of partisan symmetry has old roots[1]. A particularly simple measure is to ask how many seats each party would win if it attained the same statewide share of the vote; in this report I refer to the difference between the two seat counts as partisan seat asymmetry. Partisan seat asymmetry can also be calculated for a variety of likely swings in voter behavior; in this case, the average amount of asymmetry serves as a straightforward measure of partisan advantage over a range of plausible scenarios.

Another method for evaluating the fairness in the number of seats, given a total statewide vote, is the efficiency gap. The efficiency gap measures how far a pattern of outcomes deviates from expectations for a particular statewide vote, and is therefore a way of quantifying partisan advantage (though not necessarily a bright-line test)[2]. It has been proposed that an efficiency gap of 7 percentage points be used as a threshold to define undue advantage. However, it must be noted that the efficiency gap can jump in value when a single close race is won or lost. Therefore it is helpful to average the efficiency gap across a range of scenarios.

B. The mean-median difference

The mean-median difference is a long-standing measure of what statisticians call skewness[3]. Applied to a district plan, the mean-median difference provides one way of testing whether an unusual pattern of districts is found above or below the statewide average. Such an unusual pattern is one way that an artful redistricting plan can build systematic advantage for one party. The mean-median difference can often help detect undue partisan advantage in a closely divided state such as North Carolina[4].

C. Tests of voter packing

When one side's voters are packed into a few districts to reduce their opportunities to elect representatives, they will be present in unusually large numbers in those districts. A direct way to measure packing is to compare the average vote share of Democratic-leaning and Republican-leaning districts. The party with the larger average win is potentially packed by its opponents in order to dilute

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[1] Gill v. Whitford, 138 S. Ct. 1916, 1933 (2018).(citing Brief of Heather K. Gerken et al. as Amici Curiae Supporting Appellees at 27.

[2] Eric McGhee, *Symposium: The efficiency gap is a measure, not a test.* SCOTUSblog, August 11, 2017. https://www.scotusblog.com/2017/08/symposium-efficiency-gap-measure-not-test/ (last visited on February 21, 2022).

[3] David P. Doane & Lori E. Seward, Measuring Skewness: A Forgotten Statistic?, J. STAT. EDUC., July 2011, at 9-10; Karl Pearson, Contributions to the Mathematical Theory of Evolution—1: Skew Variation in Homogeneous Material, PHIL.TRANSACTIONS ROYAL SOC'Y, 1895, at 343, 374-76.

[4] Samuel S.-H. Wang, Three Tests for Practical Evaluation of Partisan Gerrymandering, 68 STAN. L. REV. 1263, 1263–1321 (2016); Michael D. McDonald & Robin E. Best, Unfair Partisan Gerrymanders in Politics and Law1: A Diagnostic Applied to Six Cases, 14 ELECTION L.J. 312, 312 (2015).

voting power. The concept of comparing averages dates to the foundations of statistics[5], and when applied to redistricting such a comparison is called the “lopsided-wins test”.

A more recent measure of packing is the declination, a measure that can be read from a graph visually. Declination takes advantage of the fact that a pattern of packing induces an elbow-like shape in the graph. The amount of bend in the elbow defines the declination. Declination also makes use of the number of districts won by each party. the larger the declination, the more voters are packed into a small number of districts.

III. ELECTION DATA AND ANALYSIS METHODS

I estimated the likely performance of Congressional, Senate, and House maps in two ways. First, I evaluated vote totals in the proposed districts using ten statewide elections from 2014 to 2020. Second, I allowed the vote totals to vary above and below an average of these elections, as a means of evaluating a range of future scenarios that may arise in the coming decade. After these two steps, I then evaluated a variety of measures of partisan symmetry.

I used datasets for the following elections:

- President: 2016, 2020
- Senate: 2014, 2016, 2020
- Governor: 2016, 2020
- Lieutenant Governor: 2016, 2020
- Attorney General: 2016, 2020

In these elections, the two-party vote share ranged between 46.7% and 52.3% for Democrats, and between 47.7% and 53.3% for Republicans.

In addition, I used a composite (“2016-2020 Composite”) that is averaged with equal weights from three components: (1) the average of President 2016 and 2020, (2) the average of Senate 2016 and 2020, and (3) the average of Governor and Attorney General 2020. In the 2016-2020 Composite, the two-party vote share was 49.0% for Democrats and 51.0% for Republicans.

IV. EVALUATION OF CONGRESSIONAL REMEDIAL PLANS

A. Legislative Defendants’ Plan

As an example of how the analysis is done, **Exhibit 1** shows calculations for the Legislative Defendants’ plan in district-by-district form, using the 2016-2020 Composite. The plan is also evaluated according to the 10 individual election datasets (**Exhibit 2**).

[5] Rigorous methods for comparing averages were first developed for controlling the quality of ingredients in the production of Guinness beer. The “Student t test” was devised by a master brewer, William Sealy Gossett, working pseudonymously to protect the trade secret. S.L. Zabell, “On Student’s 1908 Article ‘The Probable Error of a Mean’”, 103 JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION 1.

For all 10 election datasets evaluated, the projected outcome for the Legislative Defendants' map was always between 4 and 8 Democratic seats, and between 6 and 10 Republican seats. The average outcome for the 10 election datasets was 5.3 Democratic seats and 8.7 Republican seats.

Exhibit 1: A fairness "dashboard" for the Legislative Defendants' remedial Congressional plan. Pink shading indicates Republican advantage, and blue shading indicates Democratic advantage.

LEGISLATIVE DEFENDANTS' CONGRESSIONAL PLAN

District	D share	R share	Margin (%)
1	54.7%	45.3%	9.5
2	64.8%	35.2%	29.7
3	38.7%	61.3%	-22.5
4	67.5%	32.5%	35.1
5	44.2%	55.8%	-11.6
6	50.6%	49.4%	1.2
7	50.6%	49.4%	1.1
8	42.0%	58.0%	-16.0
9	38.7%	61.3%	-22.6
10	29.5%	70.5%	-40.9
11	44.9%	55.1%	-10.2
12	67.4%	32.6%	34.8
13	48.5%	51.5%	-2.9
14	48.9%	51.1%	-2.2
		-1.3	average margin

DISTRICT RATINGS	
6	D favored
8	R favored
4	competitive within 7 points
PROBABILISTIC OUTCOME	
5.8	Expected D wins
8.2	Expected R wins

LOPSIDED WINS	
59.3	Average D win voteshare (%)
58.1	Average R win voteshare (%)
1.2	R advantage

PARTISAN ASYMMETRY	
6.3	D seats in 50-50 election
7.7	R seats in 50-50 election
1.4	R seat advantage
2.4	average R seat advantage

MEAN-MEDIAN DIFFERENCE	
-1.26%	mean D-R (margin %)
-2.58%	median D-R (margin %)
0.7%	R advantage (vote %)

DECLINATION	
11.4	R advantage

EFFICIENCY GAP	
7.4%	R advantage (averaged)

Exhibit 2: Evaluation of the Legislative Defendants' remedial Congressional plan using data from ten elections.

	Lt. Gov. 2016	Senator 2016	President 2016	Lt. Gov. 2020	Senator 2020	Senator 2014	President 2020	Attorney Gen 2020	Attorney Gen 2016	Governor 2020	10-election average	2016-2020 composite
Democratic vote share (two-party)	46.7%	47.0%	48.1%	48.3%	49.1%	49.2%	49.3%	50.1%	50.3%	52.3%	49.0%	49.3%
Democratic seats	4	4	4	4	6	6	5	6	6	8	5.3	6
Republican seats	10	10	10	10	8	8	9	8	8	6	8.7	8
Partisan seat asymmetry	1	2	3	2	0	2	1	2	2	2	1.7	2
Mean-median difference	2.7%	2.1%	1.3%	0.3%	0.7%	2.1%	-0.1%	0.3%	2.2%	0.1%	1.2%	0.7%
Partisan bias	3.2%	4.1%	5.4%	4.8%	5.0%	5.2%	5.2%	5.1%	5.7%	4.5%	4.8%	5.2%
Lopsided wins difference	2.6%	4.2%	10.3%	10.4%	0.9%	0.6%	7.8%	5.2%	5.3%	4.2%	5.1%	2.4%
Declination angle (degrees)	28.5	30.5	37.3	37.9	9.1	8.5	27.0	15.7	15.9	-1.0	20.9	11.4
Efficiency gap	14.4%	14.1%	11.3%	10.0%	7.5%	8.3%	5.6%	2.4%	4.3%	-9.5%	6.8%	7.4%

Pink shading indicates a Republican advantage. Blue indicates a Democratic advantage.
The efficiency gap for the 2016-2020 composite is averaged over a range of possibilities within 7 points of the composite.

1. Partisan seat asymmetry

I calculated the partisan seat asymmetry, i.e. the difference in seat breakdown that would result if the two parties traded total vote shares. I did this by creating a counterfactual in which I added a fixed percentage to the vote share in all districts, an assumption called "uniform swing.' In 9 out of 10 cases[6], Republicans won more seats than the Democrats with the same vote share. For example, using the Governor 2020 race, Democrats win 52.3% of the vote and get 8 out of 14 districts. In my counterfactual, if Republicans win 52.3% of the vote, they would get 10 out of 14 districts. The difference between 10 and 8 is 2 - in other words, this plan has 2-seat partisan seat asymmetry.

Averaging across all 10 elections, the advantage was 1.7 more seats for Republicans, or 12% of the 14-seat Congressional delegation.

To test the robustness of this finding, I re-calculated the partisan seat asymmetry by taking the 2016-2020 composite and adding uniform swings to create scenarios in which Democrats and Republicans win an additional margin up to 7 points on top of their performance in the 2016-2020 composite. In each of these scenarios, I then calculated the partisan seat asymmetry as previously described. Averaging across these scenarios, the partisan seat asymmetry was again 1.7 seats favoring Republicans.

To summarize the partisan seat asymmetry analysis: The Legislative Defendants' remedial plan contains an average advantage of approximately 1.7 Congressional seats for Republicans, and this advantage persists across a wide range of likely scenarios that may arise.

2. Metrics of partisan fairness

I then calculated five metrics that are used to test for partisan advantage: (a) the mean-median difference, (b) partisan bias, (c) lopsided wins, (d) the efficiency gap, and (e) the declination. I found that for all five tests, the metric showed an advantage for Republicans.

Across 10 elections, the average mean-median difference was 1.2% favoring Republicans.

I calculated the efficiency gap for a variety of scenarios, in the same way that I calculated partisan seat asymmetry: I added uniform swings to create scenarios in which Democrats and Republicans win an additional margin up to 7 points on top of their performance in the 2016-2020 composite. Under these assumptions, the average efficiency gap was 6.8% favoring Republicans. In six out of 10 election datasets, the efficiency gap was greater than 7%.

B. Comparisons with the Harper and NCLCV Plans

To compare the Legislative Defendants' plan with two other Congressional plans offered by the Harper plaintiffs and the North Carolina League of Conservation Voters (NCLCV), I evaluated all three plans using the 2016-2020 Composite. This Composite has two advantages: it is close to 50% for each party

[6] The only case where there was no asymmetry was Senator 2020.

(favoring Republicans slightly), and it averages out effects that may be peculiar to a specific election or type of office.

The results are shown below in **Exhibit 3**.

Exhibit 3: Comparison of Legislative Defendants' Congressional Plan, the Harper plaintiffs' plan, and the NCLCV's plan.

	Legislative Defendants	Harper plaintiffs	NCLCV
Statewide Democratic vote share (2016-2020 composite)	49.3%	49.3%	49.3%
Estimated performance:			
Democratic-favored seats	6	7	8
Republican-favored seats	8	7	6
minimum Democratic seats	4	5	4
maximum Democratic seats	8`	8	8
Asymmetry measures (positive = Republican advantage):			
Seat partisan asymmetry	1.7 seats	0.2 seats	-0.6 seats
Technical metrics:			
Mean-median difference	0.7%	0.1%	-1.7%
Partisan bias	5.2%	1.0%	-0.4%
Lopsided wins difference	2.4%	-2.3%	-9.9%
Declination angle	11.4°	-3.1°	-18.6°
Efficiency gap	7.4%	1.1%	-0.5%
Color key:			
Democratic advantage	Republican advantage		

First, it should be noted that the Legislative Defendants' plan has 6 Democratic-favored districts, the Harper plaintiffs' plan has 7 Democratic-favored districts, and the NCLCV plan has 8 Democratic-favored districts. However, such an estimate does not capture the full complexity of the pattern of districts as constructed in each plan. For this reason it is helpful to evaluate the other measures. The Legislative Defendants' plan shows favor to Republicans in all six measures tested. The NCLCV plan shows favor to Democrats in all six measures.

The Harper plaintiffs' plan shows no clear pattern of advantages to either party. The metrics for the Harper plain are generally close to zero, including seat partisan asymmetry of 0.2 seat, a mean-median difference of 0.1%, and an efficiency gap of 1.1%. The smallness and mixed nature of these metrics indicates that the Harper plaintiffs' plan is balanced in a way that gives special favor to neither Democrats or Republicans.

Dashboards for the Harper and NCLCV plaintiffs' plans are given in **Exhbits 4 and 5**.

Exhibit 4: Fairness dashboard for the Harper plaintiffs' Congressional plan.

HARPER PLAINTIFFS' CONGRESSIONAL PLAN

District	D share	R share	Margin (%)
1	54.6%	45.4%	9.2
2	63.9%	36.1%	27.9
3	38.5%	61.5%	-23.0
4	67.1%	32.9%	34.1
5	34.9%	65.1%	-30.2
6	61.0%	39.0%	22.0
7	42.7%	57.3%	-14.5
8	31.8%	68.2%	-36.3
9	48.3%	51.7%	-3.5
10	32.7%	67.3%	-34.6
11	44.9%	55.1%	-10.2
12	68.6%	31.4%	37.2
13	52.5%	47.5%	5.1
14	50.5%	49.5%	1.0
		-1.1	average margin

DISTRICT RATINGS	
7	D favored
7	R favored
3	competitive within 7 points
PROBABILISTIC OUTCOME	
6.7	Expected D wins
7.3	Expected R wins

LOPSIDED WINS	
59.7	Average D win voteshare (%)
60.9	Average R win voteshare (%)
-1.1	D advantage

PARTISAN ASYMMETRY	
6.9	D seats in 50-50 election
7.1	R seats in 50-50 election
0.2	R seat advantage
0.8	average R seat advantage

MEAN-MEDIAN DIFFERENCE	
-1.14%	mean D-R (margin %)
-1.23%	median D-R (margin %)
0.05%	R advantage (vote %)

DECLINATION	
-3.1	D advantage

EFFICIENCY GAP	
1.1%	R advantage (averaged)

Exhibit 5: Fairness dashboard for the NCLCV plaintiffs' Congressional plan.

NCLCV PLAINTIFFS' CONGRESSIONAL PLAN

District	D share	R share	Margin (%)
1	46.2%	53.8%	-7.7
2	51.9%	48.1%	3.7
3	40.3%	59.7%	-19.3
4	51.8%	48.2%	3.6
5	65.0%	35.0%	29.9
6	64.0%	36.0%	28.0
7	50.5%	49.5%	0.9
8	32.3%	67.7%	-35.4
9	66.7%	33.3%	33.4
10	52.4%	47.6%	4.9
11	53.9%	46.1%	7.7
12	40.4%	59.6%	-19.1
13	32.3%	67.7%	-35.5
14	44.9%	55.1%	-10.2
		-1.1	average margin

DISTRICT RATINGS	
8	D favored
6	R favored
4	competitive within 7 points
PROBABILISTIC OUTCOME	
7.1	Expected D wins
6.9	Expected R wins

LOPSIDED WINS	
57.0	Average D win voteshare (%)
60.6	Average R win voteshare (%)
-3.6	D advantage

PARTISAN ASYMMETRY	
7.4	D seats in 50-50 election
6.6	R seats in 50-50 election
-0.8	D seat advantage
-0.6	average D seat advantage

MEAN-MEDIAN DIFFERENCE	
-1.08%	mean D-R (margin %)
2.24%	median D-R (margin %)
-1.66%	D advantage (vote %)

DECLINATION	
-18.6	D advantage

EFFICIENCY GAP	
-0.5%	D advantage (averaged)

V. EVALUATION OF STATE SENATE REMEDIAL PLANS

A. The Legislative Defendants' remedial plan

A comparison of metrics for the Legislative Defendants' remedial Senate plan, as well as the Harper plaintiffs' and NCLVL plaintiffs' proposed plans, are shown in **Exhibit 6**. Individual dashboards for the three plans are shown in **Exhibits 7, 8, and 9**.

The Legislative Defendants' plan favors 22 Democrats and 28 Republicans as scored according to the 2016-2020 election composite (**Exhibit 6**). The range of likely outcomes is 19 to 26 Senate seats for Democrats, and 24 to 31 Senate seats for Republicans. The seat partisan asymmetry is a 2.1-seat difference in favor of Republicans. All of the five other metrics also favor Republicans. This plan contains 7 competitive races, as defined as margins of 7 percentage points or smaller (**Exhibit 7**).

A. The Harper plaintiffs' and NCLCV plaintiffs' plans

The Harper plaintiffs' plan favors 22 Democrats and 28 Republicans. The range of likely outcomes is 21 to 28 Senate seats for Democrats, and 22 to 29 Senate seats for Republicans. The seat partisan asymmetry is a 1.3-seat difference in favor of Democrats. The five other metrics are of mixed effect, showing no clear advantage. This plan contains 7 competitive races (**Exhibit 8**).

The NCLCV plaintiffs' plan favors 24 Democrats and 26 Republicans. The range of likely outcomes is 19 to 28 Senate seats for Democrats, and 22 to 31 Senate seats for Republicans. The seat partisan asymmetry is a 1.3-seat difference in favor of Democrats. The five other metrics are of mixed effect, showing no clear advantage. This plan contains 9 competitive races (**Exhibit 9**).

Exhibit 6: Comparison of state Senate plans.

	Legislative Defendants	Harper plaintiffs	NCLCV
Statewide Democratic vote share (2016-2020 composite)	49.3%	49.3%	49.3%
Estimated performance:			
Democratic-favored seats	22	22	24
Republican-favored seats	28	28	26
minimum Democratic seats	19	21	19
maximum Democratic seats	26	28	28
competitive races (margin <7 points)	7	7	9
Asymmetry measures (positive = Republican advantage):			
Seat partisan asymmetry	2.1 seats	1.3 seats	1.3 seats
Technical metrics:			
Mean-median difference	0.8%	-0.1%	-0.1%
Partisan bias	4.2%	1.1%	1.6%
Lopsided wins difference	4.0%	3.5%	0.0%
Declination angle	11.4°	11.1°	2.3°
Efficiency gap	2.2%	-0.9%	-0.9%

Color key:	
Democratic advantage	Republican advantage

Exhibit 7: Fairness dashboard for the Legislative Defendants' state Senate remedial plan.

LEGISLATIVE DEFENDANTS' SENATE PLAN

District	D share	R share	Margin (%)
1	38.7%	61.3%	-22.5
2	42.2%	57.8%	-15.6
3	53.5%	46.5%	7.1
4	48.0%	52.0%	-3.9
5	57.2%	42.8%	14.4
6	34.6%	65.4%	-30.9
7	49.4%	50.6%	-1.2
8	39.8%	60.2%	-20.3
9	40.1%	59.9%	-19.8
10	37.8%	62.2%	-24.3
11	51.2%	48.8%	2.4
12	40.6%	59.4%	-18.9
13	63.7%	36.3%	27.4
14	71.9%	28.1%	43.7
15	67.6%	32.4%	35.2
16	65.0%	35.0%	30.1
17	50.9%	49.1%	1.8
18	51.2%	48.8%	2.4
19	55.7%	44.3%	11.3
20	72.3%	27.7%	44.5
21	49.7%	50.3%	-0.7
22	79.1%	20.9%	58.2
23	66.1%	33.9%	32.1
24	49.5%	50.5%	-1.0
25	40.7%	59.3%	-18.5
26	42.7%	57.3%	-14.5
27	57.1%	42.9%	14.2
28	75.8%	24.2%	51.5
29	33.2%	66.8%	-33.5
30	27.3%	72.7%	-45.4
31	44.6%	55.4%	-10.7
32	59.9%	40.1%	19.9
33	30.7%	69.3%	-38.6
34	44.8%	55.2%	-10.4
35	37.0%	63.0%	-25.9
36	23.8%	76.2%	-52.5
37	34.8%	65.2%	-30.4
38	80.1%	19.9%	60.3
39	64.8%	35.2%	29.6
40	70.5%	29.5%	41.0
41	67.6%	32.4%	35.1
42	54.6%	45.4%	9.1
43	37.4%	62.6%	-25.3
44	30.5%	69.5%	-39.0
45	30.0%	70.0%	-40.0
46	38.6%	61.4%	-22.7
47	36.8%	63.2%	-26.4
48	35.8%	64.2%	-28.3
49	63.2%	36.8%	26.3
50	36.2%	63.8%	-27.6

DISTRICT RATINGS	
22	D favored
28	R favored
7	competitive within 7 points
PROBABILISTIC OUTCOME	
22.5	Expected D wins
27.5	Expected R wins

LOPSIDED WINS	
63.6	Average D win voteshare (%)
61.6	Average R win voteshare (%)
2.0	R advantage

PARTISAN ASYMMETRY	
23.2	D seats for 50-50 vote
26.8	R seats for 50-50 vote
3.7	R seat advantage
2.1	average R seat advantage

MEAN-MEDIAN DIFFERENCE	
-1.0%	mean D-R (margin %)
-2.6%	median D-R (margin %)
0.8%	R advantage (vote %)

DECLINATION (angle, in degrees)	
11.4	R advantage

EFFICIENCY GAP	
2.2%	R advantage

Exhibit 8: Fairness dashboard for the Harper plaintiffs' state Senate plan.

HARPER PLAINTIFFS' SENATE PLAN

District	D share	R share	Margin (%)
1	38.7%	61.3%	-22.5
2	42.2%	57.8%	-15.6
3	53.5%	46.5%	7.1
4	48.0%	52.0%	-3.9
5	57.2%	42.8%	14.4
6	34.6%	65.4%	-30.9
7	49.6%	50.4%	-0.9
8	40.0%	60.0%	-20.0
9	40.1%	59.9%	-19.8
10	37.8%	62.2%	-24.3
11	51.2%	48.8%	2.4
12	40.6%	59.4%	-18.9
13	59.0%	41.0%	17.9
14	66.3%	33.7%	32.5
15	55.9%	44.1%	11.9
16	77.7%	22.3%	55.4
17	58.3%	41.7%	16.6
18	54.2%	45.8%	8.4
19	55.6%	44.4%	11.1
20	78.7%	21.3%	57.3
21	49.6%	50.4%	-0.7
22	72.8%	27.2%	45.6
23	66.1%	33.9%	32.1
24	49.5%	50.5%	-1.0
25	41.8%	58.2%	-16.4
26	49.1%	50.9%	-1.7
27	56.5%	43.5%	13.0
28	67.3%	32.7%	34.6
29	33.0%	67.0%	-33.9
30	27.3%	72.7%	-45.4
31	49.7%	50.3%	-0.5
32	56.2%	43.8%	12.3
33	30.7%	69.3%	-38.6
34	44.8%	55.2%	-10.4
35	36.2%	63.8%	-27.6
36	24.1%	75.9%	-51.8
37	35.2%	64.8%	-29.6
38	80.5%	19.5%	61.0
39	61.3%	38.7%	22.6
40	69.2%	30.8%	38.4
41	67.5%	32.5%	35.1
42	57.9%	42.1%	15.7
43	38.4%	61.6%	-23.1
44	31.1%	68.9%	-37.8
45	30.1%	69.9%	-39.7
46	28.2%	71.8%	-43.6
47	37.0%	63.0%	-26.0
48	46.0%	54.0%	-8.0
49	60.2%	39.8%	20.5
50	35.6%	64.4%	-28.8

DISTRICT RATINGS	
22	D favored
28	R favored
7	competitive within 7 points
PROBABILISTIC OUTCOME	
23.8	Expected D wins
26.2	Expected R wins

LOPSIDED WINS	
62.9	Average D win voteshare (%)
61.1	Average R win voteshare (%)
1.8	R advantage

PARTISAN ASYMMETRY	
24.6	D seats for 50-50 vote
25.4	R seats for 50-50 vote
0.8	R seat advantage
-1.3	average D seat advantage

MEAN-MEDIAN DIFFERENCE	
-1.1%	mean D-R (margin %)
-1.0%	median D-R (margin %)
-0.1%	D advantage (vote %)

DECLINATION (angle, in degrees)	
11.1	R advantage

EFFICIENCY GAP	
-0.9%	D advantage

Exhibit 9: Fairness dashboard for the NCLCV plaintiffs' state Senate plan.

NCLCV PLAINTIFFS' SENATE PLAN

District	D share	R share	Margin (%)
1	53.5%	46.5%	7.1
2	38.7%	61.3%	-22.5
3	42.2%	57.8%	-15.6
4	48.0%	52.0%	-3.9
5	57.2%	42.8%	14.4
6	34.6%	65.4%	-30.9
7	51.9%	48.1%	3.8
8	38.4%	61.6%	-23.3
9	40.1%	59.9%	-19.8
10	37.8%	62.2%	-24.3
11	51.2%	48.8%	2.4
12	40.6%	59.4%	-18.9
13	51.0%	49.0%	1.9
14	73.1%	26.9%	46.1
15	65.3%	34.7%	30.5
16	64.5%	35.5%	29.0
17	52.0%	48.0%	3.9
18	65.5%	34.5%	31.1
19	66.5%	33.5%	32.9
20	72.0%	28.0%	44.0
21	39.9%	60.1%	-20.2
22	79.6%	20.4%	59.2
23	66.1%	33.9%	32.1
24	49.5%	50.5%	-1.0
25	40.5%	59.5%	-19.1
26	51.4%	48.6%	2.8
27	59.0%	41.0%	17.9
28	62.6%	37.4%	25.2
29	33.4%	66.6%	-33.2
30	27.3%	72.7%	-45.4
31	49.3%	50.7%	-1.4
32	57.6%	42.4%	15.1
33	30.7%	69.3%	-38.6
34	44.8%	55.2%	-10.3
35	37.0%	63.0%	-25.9
36	24.1%	75.9%	-51.8
37	36.6%	63.4%	-26.9
38	66.6%	33.4%	33.1
39	73.1%	26.9%	46.3
40	72.5%	27.5%	45.0
41	54.4%	45.6%	8.9
42	68.8%	31.2%	37.6
43	38.2%	61.8%	-23.7
44	31.1%	68.9%	-37.8
45	29.7%	70.3%	-40.6
46	28.5%	71.5%	-42.9
47	36.8%	63.2%	-26.3
48	49.7%	50.3%	-0.7
49	56.6%	43.4%	13.3
50	36.4%	63.6%	-27.2

DISTRICT RATINGS	
24	D favored
26	R favored
9	competitive within 7 points
PROBABILISTIC OUTCOME	
24.1	Expected D wins
25.9	Expected R wins

LOPSIDED WINS	
62.2	Average D win voteshare (%)
62.2	Average R win voteshare (%)
0.0	R advantage

PARTISAN ASYMMETRY	
24.8	D seats for 50-50 vote
25.2	R seats for 50-50 vote
0.5	R seat advantage
-1.3	average D seat advantage

MEAN-MEDIAN DIFFERENCE	
-1.0%	mean D-R (margin %)
-0.8%	median D-R (margin %)
-0.1%	D advantage (vote %)

DECLINATION (angle, in degrees)	
2.3	R advantage

EFFICIENCY GAP	
-0.9%	D advantage

Exhibit 10: Comparison of state House plans.

	Legislative Defendants	NCLCV
Democratic vote share (two-party)	49.3%	49.3%
Democratic-majority seats	57	58
Republican-majority seats	63	62
minimum Democratic seats	47	51
maximum Democratic seats	64	65
Seat partisan asymmetry	7.2	4.1
Mean-median difference	0.9%	1.1%
Partisan bias	2.7%	1.7%
Lopsided wins difference	7.1%	3.5%
Declination angle (degrees)	4.5	2.7
Efficiency gap	3.0%	1.6%

Color key:

Democratic advantage	Republican advantage

Exhibit 11: Fairness dashboard for the Legislative defendants' state House plan.

LEGISLATIVE DEFENDANTS' REMEDIAL HOUSE PLAN

District	D %	R %	Margin (%)
1	38.0%	62.0%	-23.9
2	55.9%	44.1%	11.8
3	40.4%	59.6%	-19.2
4	40.6%	59.4%	-18.7
5	51.1%	48.9%	2.2
6	43.4%	56.6%	-13.2
7	43.8%	56.2%	-12.4
8	58.2%	41.8%	16.3
9	51.4%	48.6%	2.8
10	46.2%	53.8%	-7.7
11	66.1%	33.9%	32.2
12	47.3%	52.7%	-5.4
13	30.7%	69.3%	-38.6
14	37.1%	62.9%	-25.7
15	35.8%	64.2%	-28.4
16	33.0%	67.0%	-34.0
17	39.1%	60.9%	-21.7
18	55.1%	44.9%	10.2
19	38.9%	61.1%	-22.1
20	49.5%	50.5%	-1.1
21	66.7%	33.3%	33.4
22	42.2%	57.8%	-15.7
23	60.7%	39.3%	21.4
24	51.8%	48.2%	3.6
25	52.0%	48.0%	4.0
26	42.2%	57.8%	-15.6
27	63.1%	36.9%	26.2
28	33.8%	66.2%	-32.4
29	83.8%	16.2%	67.5
30	85.6%	14.4%	71.2
31	81.2%	18.8%	62.4
32	57.3%	42.7%	14.6
33	62.8%	37.2%	25.6
34	62.0%	38.0%	24.1
35	51.1%	48.9%	2.2
36	56.2%	43.8%	12.4
37	47.3%	52.7%	-5.4
38	85.4%	14.6%	70.9
39	61.2%	38.8%	22.4
40	54.7%	45.3%	9.4
41	63.1%	36.9%	26.3
42	71.2%	28.8%	42.3
43	49.6%	50.4%	-0.8

DISTRICT RATINGS	
57	D favored
63	R favored
17	competitive within 7 points
PROBABILISTIC OUTCOME	
55.9	Expected D wins
64.1	Expected R wins

LOPSIDED WINS	
64.0	Average D win voteshare (%)
63.2	Average R win voteshare (%)
0.8	R advantage (%)

PARTISAN ASYMMETRY	
56.7	D seats in 50-50 election
63.3	R seats in 50-50 election
4.0	R seat advantage
7.2	average R seat advantage

MEAN-MEDIAN DIFFERENCE	
-0.6%	mean D-R margin (%)
-2.4%	median D-R margin (%)
0.9%	R advantage

DECLINATION ANGLE (degrees)	
4.5	R advantage

EFFICIENCY GAP	
3.1%	R advantage (averaged)

44	62.3%	37.7%	24.6
45	57.4%	42.6%	14.8
46	37.9%	62.1%	-24.1
47	49.1%	50.9%	-1.9
48	54.6%	45.4%	9.2
49	67.7%	32.3%	35.3
50	57.5%	42.5%	15.1
51	40.7%	59.3%	-18.6
52	43.5%	56.5%	-13.0
53	35.2%	64.8%	-29.6
54	53.8%	46.2%	7.6
55	41.6%	58.4%	-16.7
56	85.9%	14.1%	71.8
57	57.6%	42.4%	15.2
58	73.0%	27.0%	46.0
59	50.3%	49.7%	0.7
60	62.3%	37.7%	24.6
61	80.7%	19.3%	61.4
62	50.3%	49.7%	0.6
63	52.2%	47.8%	4.5
64	40.5%	59.5%	-18.9
65	35.8%	64.2%	-28.5
66	70.7%	29.3%	41.4
67	28.9%	71.1%	-42.3
68	38.3%	61.7%	-23.5
69	34.8%	65.2%	-30.4
70	24.6%	75.4%	-50.9
71	71.0%	29.0%	42.1
72	75.2%	24.8%	50.5
73	50.9%	49.1%	1.9
74	47.5%	52.5%	-4.9
75	44.4%	55.6%	-11.1
76	39.2%	60.8%	-21.6
77	24.7%	75.3%	-50.6
78	26.3%	73.7%	-47.5
79	38.7%	61.3%	-22.6
80	25.6%	74.4%	-48.8
81	28.9%	71.1%	-42.2
82	46.2%	53.8%	-7.6
83	25.9%	74.1%	-48.2
84	33.9%	66.1%	-32.2
85	27.6%	72.4%	-44.8
86	31.5%	68.5%	-37.0
87	27.2%	72.8%	-45.5
88	69.5%	30.5%	39.0
89	26.0%	74.0%	-48.0
90	24.9%	75.1%	-50.1

91	30.9%	69.1%	-38.3
92	69.3%	30.7%	38.6
93	42.9%	57.1%	-14.2
94	24.0%	76.0%	-52.1
95	34.5%	65.5%	-30.9
96	37.1%	62.9%	-25.7
97	27.5%	72.5%	-45.0
98	48.6%	51.4%	-2.8
99	84.1%	15.9%	68.2
100	75.9%	24.1%	51.8
101	76.6%	23.4%	53.2
102	78.9%	21.1%	57.8
103	51.1%	48.9%	2.3
104	54.3%	45.7%	8.6
105	55.9%	44.1%	11.8
106	69.0%	31.0%	38.0
107	82.3%	17.7%	64.5
108	32.9%	67.1%	-34.3
109	40.8%	59.2%	-18.5
110	33.3%	66.7%	-33.5
111	31.2%	68.8%	-37.7
112	61.2%	38.8%	22.5
113	34.3%	65.7%	-31.4
114	65.7%	34.3%	31.3
115	55.1%	44.9%	10.2
116	59.3%	40.7%	18.6
117	40.4%	59.6%	-19.2
118	38.5%	61.5%	-22.9
119	43.9%	56.1%	-12.1
120	27.0%	73.0%	-46.1

Exhibit 12: Fairness dashboard for the NCLCV plaintiffs' state House plan.

NCLCV PLAINTIFFS' HOUSE PLAN

District	D %	R %	Margin (%)
1	40.9%	59.1%	-18.3
2	58.1%	41.9%	16.2
3	40.4%	59.6%	-19.2
4	35.5%	64.5%	-29.0
5	51.1%	48.9%	2.2
6	41.9%	58.1%	-16.3
7	43.9%	56.1%	-12.3
8	55.8%	44.2%	11.5
9	53.6%	46.4%	7.3
10	51.8%	48.2%	3.7
11	66.2%	33.8%	32.4
12	47.3%	52.7%	-5.4
13	30.7%	69.3%	-38.6
14	29.3%	70.7%	-41.4
15	49.3%	50.7%	-1.4
16	32.7%	67.3%	-34.6
17	52.3%	47.7%	4.6
18	55.3%	44.7%	10.6
19	35.0%	65.0%	-30.0
20	41.9%	58.1%	-16.2
21	54.2%	45.8%	8.3
22	42.2%	57.8%	-15.7
23	60.7%	39.3%	21.4
24	51.9%	48.1%	3.9
25	51.9%	48.1%	3.8
26	43.8%	56.2%	-12.4
27	63.1%	36.9%	26.2
28	35.0%	65.0%	-29.9
29	84.2%	15.8%	68.4
30	82.0%	18.0%	64.0
31	80.9%	19.1%	61.7
32	57.3%	42.7%	14.6
33	84.7%	15.3%	69.4
34	63.5%	36.5%	27.0
35	50.6%	49.4%	1.1
36	59.4%	40.6%	18.8
37	47.5%	52.5%	-5.0
38	65.7%	34.3%	31.4
39	59.7%	40.3%	19.4
40	69.8%	30.2%	39.7
41	66.6%	33.4%	33.2
42	54.8%	45.2%	9.6
43	53.7%	46.3%	7.4

DISTRICT RATINGS	
58	D favored
62	R favored
14	competitive within 7 points
PROBABILISTIC OUTCOME	
57.3	Expected D wins
62.7	Expected R wins

LOPSIDED WINS	
63.9	Average D win voteshare (%)
63.5	Average R win voteshare (%)
0.4	R advantage (%)

PARTISAN ASYMMETRY	
57.8	D seats in 50-50 election
62.2	R seats in 50-50 election
4.0	R seat advantage
4.1	average R seat advantage

MEAN-MEDIAN DIFFERENCE	
-0.5%	mean D-R margin (%)
-2.8%	median D-R margin (%)
1.1%	R advantage

DECLINATION ANGLE (degrees)	
2.7	R advantage

EFFICIENCY GAP	
1.9%	R advantage (averaged)

44	72.4%	27.6%	44.9
45	60.5%	39.5%	20.9
46	40.0%	60.0%	-20.0
47	46.8%	53.2%	-6.4
48	54.6%	45.4%	9.2
49	65.3%	34.7%	30.5
50	56.7%	43.3%	13.3
51	34.9%	65.1%	-30.2
52	41.3%	58.7%	-17.3
53	33.0%	67.0%	-33.9
54	58.0%	42.0%	16.1
55	43.0%	57.0%	-14.0
56	85.8%	14.2%	71.6
57	65.6%	34.4%	31.3
58	65.8%	34.2%	31.7
59	54.7%	45.3%	9.3
60	58.1%	41.9%	16.1
61	80.8%	19.2%	61.7
62	49.0%	51.0%	-2.0
63	54.2%	45.8%	8.3
64	39.2%	60.8%	-21.5
65	35.8%	64.2%	-28.5
66	63.6%	36.4%	27.2
67	28.9%	71.1%	-42.3
68	36.6%	63.4%	-26.7
69	35.2%	64.8%	-29.6
70	24.3%	75.7%	-51.4
71	69.7%	30.3%	39.4
72	74.0%	26.0%	48.1
73	44.3%	55.7%	-11.4
74	47.4%	52.6%	-5.2
75	42.6%	57.4%	-14.7
76	39.2%	60.8%	-21.6
77	24.7%	75.3%	-50.6
78	26.5%	73.5%	-47.0
79	36.0%	64.0%	-28.1
80	28.0%	72.0%	-44.1
81	26.4%	73.6%	-47.1
82	41.7%	58.3%	-16.5
83	35.2%	64.8%	-29.5
84	33.6%	66.4%	-32.8
85	27.7%	72.3%	-44.7
86	31.5%	68.5%	-37.0
87	26.6%	73.4%	-46.8
88	75.0%	25.0%	49.9
89	27.5%	72.5%	-45.0
90	24.8%	75.2%	-50.4

91	35.0%	65.0%	-30.0
92	69.5%	30.5%	39.0
93	43.0%	57.0%	-14.0
94	24.1%	75.9%	-51.8
95	34.3%	65.7%	-31.4
96	36.1%	63.9%	-27.9
97	27.5%	72.5%	-45.0
98	48.2%	51.8%	-3.5
99	59.9%	40.1%	19.9
100	69.1%	30.9%	38.2
101	75.0%	25.0%	50.0
102	80.5%	19.5%	61.1
103	50.7%	49.3%	1.4
104	56.9%	43.1%	13.7
105	57.1%	42.9%	14.2
106	83.1%	16.9%	66.2
107	76.3%	23.7%	52.7
108	32.7%	67.3%	-34.6
109	43.2%	56.8%	-13.6
110	31.5%	68.5%	-37.1
111	32.7%	67.3%	-34.7
112	75.6%	24.4%	51.2
113	33.1%	66.9%	-33.8
114	62.5%	37.5%	25.0
115	61.0%	39.0%	21.9
116	56.7%	43.3%	13.5
117	41.1%	58.9%	-17.8
118	38.5%	61.5%	-22.9
119	43.9%	56.1%	-12.1
120	27.0%	73.0%	-46.1

VIII. CONCLUSIONS

All three of the Legislative Defendants' plans favor Republicans in six metrics evaluated. The Harper plaintiffs' plans show mixed or no advantage for either party. The NCLCV plaintiffs' plans show a Democratic advantage for the Congressional plan, mixed or no advantage for the Senate plan, and a Republican advantage for the House plan. In each case, the plaintiffs' alternative(s) came closer to partisan symmetry than the Legislative Defendants' remedial maps.

Preliminary Report:

Proposed Legislative and Congressional Remedial Plans in North Carolina

Revised draft (please discared the older version)

Bernard Grofman*

March 21, 2022

* I am Jack W. Peltason Chair of Democracy Studies and Distinguished Professor of Political Science at the University of California, Irvine. My research deals primarily with issues of representation, including minority voting rights and party competition. I am a Fellow of the American Academy of Arts and Sciences. I have an honorary Ph.D. from the University of Copenhagen for my work on the cross-national study of elections and voting rules. I am the recipient of a lifetime achievement award from the American Political Science Association for my work on elections and voting rights. I am co-author of five books with major university presses (Cambridge (4), Yale (1), and co-editor of 26 other books, (including books with Oxford (3), U. Michigan (4), and Princeton) with over 300 research articles and book chapters.. Over the past six years I have served as a special master to draw remedial maps for five different federal courts, including redrawing a Virginia congressional district and redrawing eleven districts in the Virginia House of Delegates, and preparing remedial maps s in local elections in Georgia, Virginia, and Utah. In addition I served as co-special master in the 2021 redistricting, drawing the remedial maps adopted by the Virginia State Supreme Court for that state's legislative and congressional districts. Over a 40+ year career, I have served as an expert witness or consultant in redistricting cases in nearly a dozen states I have worked as an expert for both political parties, the NAACP, MALDEF, the U.S, Department of Justice, and non-partisan redistricting authorities. My work has been cited in a dozen different U.S. Supreme Court cases, perhaps most notably in *Thornburg v. Gingles* 478 U.S. 30 (1986). In mid-February 2022 I was asked to serve as an expert consultant to the three Special Masters appointed to present recommendations to the North Carolina Supreme Court in the case of *Harper v. Hall*. North Carolina maps and block equivalency files were provided by the parties in this case; North Carolina election data was provided courtesy of the Voting and Election Science Team: https://dataverse.harvard.edu/dataverse/electionscience, disseminated by Dave's Redistricting App : https://davesredistricting.org of which I made extensive use.. I am also deeply indebted to my research assistant, Zachary Griggy, for the work he provided under my direction.

I. Introduction: Thinking About Partisan Gerrymandering.

We can address the questions of partisan or racial gerrymandering either directly in terms of observed or expected political or racial consequences or, more indirectly, by examining features of maps (e.g., undue fragmentation of existing political subunits) that are often manipulated for partisan purposes. In this report my focus is on political consequences.[1]

Another useful distinction in thinking about gerrymandering is whether the focus is to be on statewide indicators of gerrymandering or on evidence of gerrymandering at the district (or additionally, in North Carolina, county cluster) level. I believe in a holistic view of gerrymandering in which we examine both statewide effects and look in detail at evidence of manipulation at the level of districts/districts within clusters. Below I discuss both approaches.[2]

(1) Using statistical metrics to directly evaluate the degree to which a map as a whole is non-dilutive in its expected partisan (or racial) consequences?

Most analyses of partisan effects of gerrymandering rely on a set of measures in the political science literature such as the *mean minus median gap*, or *partisan bias* that are applied on a jurisdiction-wide basis. These two metrics are intended to be effectively independent of the actual state-wide vote share in any given election.[3] The mean-median gap builds in the value of the statewide vote average; by comparing means and medians of the partisan distribution, it is looking at one aspect of the skewness of a distribution, which is a measure of asymmetry. The partisan bias measure is evaluated in terms of what happens when both parties get a 50% vote share, and thus checks to see if one party is advantaged when the vote share is evenly divided at

[1] Since I have written extensively on racially polarized voting and racial vote dilution, if requested, I could extend my Report to analyze racial representation in the proposed maps. But, given the intense time pressure, I have limited myself here to issues involving partisan gerrymandering.

[2] Courts have differed in how they approached this issue. One possible synthesis is to evaluate maps at the jurisdiction wide level but to determine remedies in particular districts or particular areas of the state where the key problems seemed to lie. In the racial context, the finding of violations and the remedies for gerrymandering (or for a violation of the *Shaw v. Reno* 509 U.S. 630 (1993) test for a constitutionally unlawful racially preponderant motive) have usually been localized.

[3] However, *ceteris paribus*, both methods work best when, as in North Carolina, the state-wide two party vote share is close to fifty-fifty.

the statewide level. [4] Note also that the mean-median gap and partisan bias are NOT tests for proportionality; they are tests for unequal treatment.

The best known metric to evaluate partisan inequities is *partisan bias*, one measure of which is reported for proposed NC maps in Table 1 later in the Report.[5] The *partisan bias* metric, which focuses on what happens when the vote share is 50%, implicitly incorporates what Dr. Duchin in her first expert witness report refers to as the *majoritarian principle*, namely that a majority of votes should translate into a majority of seats. As the Supreme Court said in ***Reynolds v. Sims***," to sanction minority control of state legislative bodies would appear to deny majority rights in a

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[4] Similarly, the difference between the value of the *efficiency gap* for a given plan and a value of the *efficiency gap* of zero can be taken to be an indicator of possible gerrymandering.

[5] The partisan bias test, based on symmetry, was developed by the Princeton political scientist, Edward Tufte in 1973 and the statistical methodology for calculating it was improved by the Harvard political scientist Gary King and his co-authors in the 1980s, mostly notably in joint work with the Columbia University statistician, Andrew Gelman. A relatively non-technical introduction can be found in Bernard Grofman and Gary King. "Partisan Symmetry and the Test for Gerrymandering Claims after LULAC v. Perry." 6 *Election L.J.* 2 (2007). Also see Katz Jonathan N., Gary King, and Elizabeth Rosenblatt. 2019. "Theoretical Foundations and Empirical Evaluations of Partisan Fairness in District-Based Democracies." American Political Science Review. Partisan has a simple intuition but requires a somewhat complicated method to generate results. Take a situation in which Democrats typically won approximately 53% of the statewide two-party vote. Say that with 53% of the vote Democrats would win 57% of the seats in some legislative or congressional election. Now, say that in a succeeding election, Democrats lost 6 percentage points in the popular vote so that they, not the Republicans had 47% of the popular vote. If the map were perfectly symmetric, with 53% of the vote, the Republicans also should win 57% of the seats, as the Democrats did with this same vote share. Calculating partisan symmetry requires that a researcher estimate a 50-50 election. In our example above, the researcher begins with a 53% vote share and then shifts the vote share, on average, a point at a time in both the Republican and Democratic direction while tracking the expected outcomes in seats won and lost. Then the relationship between vote share and seat share is calculated. If the parties move identically up and down what is called a votes-seats curve, the deviations should cancel out and you are left with a 0 deviation from symmetry, i.e., an estimated seat share of 50% at a vote share of 50% (i.e., vote share of 50% at a seat share of 50%). If the outcome at a 50% vote share is something other than a 50% seat share then there is partisan bias in favor of one party or the other. While this metric can be time consuming to calculate by hand, a computer can calculate this quickly. Note that a 53% vote share need not require a 53% seat share for the map to be non-dilutive. Note also that we need to a test to see if the observed level of bias is statistically significant. If a large proportion of seats are competitive, then an estimated bias may not be statistically significant, since a small change in vote share in some of the competitive seats can shift seat share substantially. This metric is the only one to attract favorable mention by some Supreme Court Justices (see Grofman and

way that far surpasses any possible denial of minority rights that might otherwise be thought to result " 377 U.S. 533 at 565 (1964).[6]

While the mean-median gap is a very useful and easy to calculate tool for getting a handle on the presence of partisan gerrymandering, it cannot stand as the sole statistical measure of partisan gerrymandering. Not only does it need to be informed by the results other measures, such as partisan bias, but it also can usefully be supplemented by measures which extend its basic approach beyond a single district.

Dr. Duchin in her first expert witness trial report (PX150, Figure 2, at p.7) shows data for the enacted congressional map and congressional ensembles. and looks at the set of most competitive districts (not just at one district, the median district). She examines whether the set of competitive districts are skewed in favor of one party. She refers to this approach as the "close votes, close seats" principle. Analogous analyses are performed by Dr. Chen in his trial testimony (see PX482, pp. 30-31). This approach can be thought of as a generalization of the mean-median gap, and is arguably to be preferred to it, since the mean-median gap only deals with results for a single district and thus can present a misleading picture of the partisan consequences of a map as a whole. Also, the mean-median gap may be easier to manipulate by mapmakers than some other measures, e.g., by assuring that in the particular district which is the median, the mean-median gap is not that big even though the map as a whole remains a clear partisan gerrymander. Nonetheless, largely because of its simplicity, the mean-median metric is an important one. I have used it myself in evaluating maps when appointed in 2021 by the Virginia Supreme Court as co-Special Master for Virginia congressional and legislative redistricting.

But, regardless of which measure of partisan vote dilution is being used, it is important to also consider how likely to be durable is the gerrymandering effect. As the Supreme Court of North Carolina observed in *Harper v. Hall*. "While partisan gerrymandering is not a new tool, modern technologies enable mapmakers to achieve extremes of imbalance that, 'with almost surgical precision,' undermine our constitutional system of government. Indeed, the programs and algorithms now available for drawing electoral districts have become so sophisticated that it is possible to implement extreme and durable partisan gerrymanders that can enable one party to effectively guarantee itself a supermajority for an entire decade, even as electoral conditions change and voter preferences shift" (slip op., p.1, footnotes omitted).

(*2) Looking at evidence of partisan manipulation <u>at the district or county cluster level</u>*

[6] The majoritarian principle is much weaker than the proportionality principle; the latter requires that a given vote share for a party translate into the identical share of legislative seats for that party. My 1985 essay, "Criteria for Districting: A Social Science Perspective." <u>UCLA Law Review</u>, 33(1):77-184," is among the many which discuss the importance of the majoritarian principle for democratic theory and election law

To look for evidence of gerrymandering at the district or county cluster requires an intensively local appraisal of how political subunits, concentrations of voters of a given party, and demographic groups are being treated (as well as of the degree to which compactness concerns were being met). This can be accomplished in two different ways.

One way is to look for evidence about intentional manipulation of boundaries at the district or county cluster level by careful use of the eyeball (and perhaps also some simple descriptive statistics) by individuals who have detailed knowledge of the state and who then provide a description of how particular pieces of geography were manipulated. Here, we can either be looking to identify areas where gerrymandering is found and to which remedies might be directed and/or we look for "patterns and practices" that are common across subunits of a kind that are indicative of gerrymandering even if we do not formally test for statistical significance[7] This type of common-sense evidence can be compelling, both at the level of individual districts and for understanding an overall pattern of dilutive acts.

The second way is to make use statistical analyses for districts or county clusters is to do analyses based on ensembles in ways that closely resemble those used for statewide analyses.

For example, one useful approach to understanding the degree to which the two key tools of gerrymandering, *packing* and *cracking,* were used by mapmakers at the district level employs ensemble analysis and calculation of statistical outliers. Dr. Jowei Chen in his expert witness trial report. Dr. Chen (PX882, Figure 4, p. 25) ranked congressional districts from most Republican to least Republican in the enacted congressional map, and considered whether there was evidence of manipulation in that the districts Republicans did best in were, in general, being won by lower than expected vote margins (i.e., the map "efficiently" placed Republican voters to win without wasting Republican votes), while the districts in which the Democrats did best were, in general, being won by higher than expected vote margins (i.e., the map "inefficiently" placed Democratic voters to "pack" them and thus waste their votes), while districts that were somewhat competitive by and large showed a higher than expected Republican votes hare (those districts were "shored up" to make Republican loss unlikely).This creates an s-shaped pattern in the data that is clearly visible in Figure 4. [8] This type of evidence suggests, even if it cannot prove, <u>intentional</u> partisan gerrymandering,

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[7]*Descriptive statistics* simply describe data and patterns in the data; *inferential statistics* seek to assign probability of occurrence of events relative to some null hypothesis. With ensemble analysis, the null hypothesis against which statistical significance is determined is that the plan was drawn from a set of plans like those in the ensemble.

[8] Chen observes statistically significant results in 10 of 14 of the county clusters and the overall pattern is striking. Here it is important not to be misled by the fact that there were some clusters that were not statistically significant; it is the overall pattern that shows the improbability of the results. Indeed, even if there were NO clusters with statistically significant results but the directionality of manipulation was as predicted across virtually all the clusters, properly applied statistical calculations that look at multiple clusters at the same time can show the reality of statistically significant results even if no <u>single</u> cluster is a statistically significant outlier. [8]

At the county cluster level, we can also evaluate whether there were excess city splits or county cuts within that cluster from what we would expect of plans in the ensemble in that same clusters. We should also note that we can ask if expected partisan outcomes within the cluster in terms of mean expected wins were extreme statistical outliers, or whether particular groups such as African-Americans or other minorities were either cracked or packed within the cluster in ways that signaled improper attention to race. But we must be careful not to mistake failures to find statistically significant results at the cluster level with the absence of significant (and substantively important) bias in the plan as a whole, since what is a clear overall pattern of discrimination can be missed if we look only small groupings.

But, in looking at districts or clusters, just as in looking at stateside indicia of partisan gerrymandering, we must also ask whether difference from what is predicted in an ensemble takes us toward partisan equity or away from it (see below).

II. Baselines and Thresholds in Evaluating Partisan Gerrymandering

What is the appropriate baseline against which to judge whether some given value of a metric such as partisan bias or mean-median difference supports a claim of egregious gerrymandering?

There are two ways in which the question of appropriate baseline for statistical analyses of partisan gerrymandering effects has been addressed in the political science literature. The most obvious way to evaluate statistical metrics used to identify partisan gerrymandering effects, such as those shown in Table 1, is simply to ask questions such as: "How close is the mean-median gap to zero?" "How close to a zero level of (vote or seat) partisan bias does the plan have?, etc. As a result of my recent experiences as a special master I have come to the view that this is not just the simplest, but also the best, way to think about statistical metrics that seek to directly measure gerrymandering. But a second way in which this question has been addressed is to ask: "How does a map compare in its properties vis-a-vis various metrics to those in an ensemble of computer drawn maps constructed in a partisan blind fashion?"

Ensembles are sets of computer-generated plans based on the geographic distribution of population in the unit (usually at the level of census blocks) which may also have "built in" instructions to the computer to take into some features besides population, e.g., respecting county or other subunit borders, or avoiding pairing incumbents, or seeking to draw compact districts.[9] For ensembles, for any given metric, the baseline is established by answer the question: "Is a given map a statistical outlier with respect to the ensemble, with properties that by chance alone would occur only at the tails of the ensemble distribution, e.g., with probability less than .05 (the familiar two standard deviation test for *adverse impact* from *Griggs v. Duke Power Co*, 401 US

[9] In North Carolina, ensemble simulations for state legislative districts (NC House and NC Senate) introduced by experts in *Harper v. Hall* are programmed to take into account, the state's county clustering rule.

424 (1971))?" Ensemble analysis can be applied to features of maps such as splitting of counties or other subunits, or features such as compactness, but it can also be applied to measuring expected political effects of a map via the kinds of metrics used by experts in the *Hall v. Harper* litigation, that were subsequently referenced in the *Harper v. Hall* majority opinion.[10] Election-related metrics are calculated using a distribution of recent partisan (and/or racial) voting patterns in the unit (usually with data drawn from statewide elections that is projected into census geography). with the values of these metrics and of expected partisan outcomes in the plan (or portions of the plan) are compared to those in the ensemble.

In evaluating any map in terms of political effect metrics it is important to be able to separate out the effects of so-called "natural" bias, i.e., partisan bias that arises from historical patterns of electoral geography and environmental features such as mountains or rivers, [11] from partisan bias that arises from contemporaneous map-making practices, including and especially intentional gerrymandering. Using ensembles as the basis for our evaluations directly allows us to compare the bias (or other features) in any given map with the bias (or other feature) in the ensemble, since we are holding constant the electoral geography of the state and other features of the state, such as rivers or mountains.

The use of ensembles has allowed for major theoretical and empirical advances in studying redistricting and gerrymandering, and I strongly endorse their previous use in this litigation. If a map exhibits more evidence of bias or other kinds of distortions than we find in an ensemble to a statistically significant degree, I view this fact as very strong *prima facie* evidence of manipulation. But there are two ways to make errors based on ensemble analyses involving political election-based metrics: on the one hand, concluding that a plan is dilutive when instead it is vote-dilution reducing and, on the other hand, concluding that a plan is not dilutive because it is not an outlier in the ensemble for some parameters when, in fact, it is a carefully crafted gerrymander (Type I and Type II errors).

First, we must be careful to look at the directionality of deviation from ensemble expectation. **If a map has lower (absolute) values on metrics such as partisan bias than most of the maps in the ensemble, *ceteris paribus*, that is something to be desired, not condemned, even if the map is outside the 95% confidence range of the ensemble. It is only when the map** has higher values of metrics that show vote dilution than most of the maps in the ensemble that we see evidence of partisan gerrymandering that might rise to the level of unconstitutionality. Thus, even if we opt only for an ensemble based approach to evaluating vote dilution, when we do look at how far from an ensemble expectation is the observed value on some metric it is critical to

[10] See, e.g., the discussion of the findings of Plaintiffs expert Dr. Jowei Chen in *League of Women Voters v. Pennsylvania* (J-1-2018, Supreme Court Of Pennsylvania Middle District).

[11] Although I have used the term "natural bias" because it has become standard, I regard it as a misnomer. For example, there is nothing natural about the disproportionate presence of African-Americans in areas good for cotton growing that continues to the present day, unless you think slavery is natural. And redlining and other practices have led to geographic segregation of minorities within cities.

distinguish whether the value in the map takes us in the direction of more dilution or in the direction of less dilution.

Second, **even if a map is within the 95% confidence bounds of an ensemble on some particular metric, that does not mean that the map is NOT a partisan gerrymander**. There are multiple statistical metrics to evaluate the level of partisan gerrymandering, and we need to be careful to look at multiple indicators, both at the state level and ones that are district or county-cluster specific. Also, there may be non-statistical evidence of intentional gerrymandering derived from careful analysis by knowledgeable observers of exactly where particular lines on the map have been drawn. Such evidence may lead to a conclusion of a constitutional violation even in the absence of use of ensembles or of statistical inference tests.[12] Or they may be inferences of intentional gerrymandering based on the redistricting process itself or based on statements made by mapmakers.

Third**, because of how ensembles are created, when we look at the political effects metrics, they may show a map to be non-dilutive even when dilution is present because the natural bias in a state favors a particular party and thus tilts the ensembles toward maps favorable to that party.**

An ensemble-based standard for vote dilution takes as given the distribution of voters in the state at some low level of census geography such as the block. But because it is built on the distribution of voters, when we look at partisan behavior in past elections, we often find that the voters of one party are more concentrated than voters in the other party. In particular, Democrats (and minorities) are likely to be highly concentrated in cities. When one group has its voters more geographically concentrated than another, redistricting can create inequities, e.g., by packing Democratic voters into districts in such a fashion as to "waste" their votes.

While I can attest from my own knowledge that Dr. Duchin (PX150, p. 4) is correct that North Carolina is a jurisdiction that has a low level of so-called natural bias compared to most other states, [13] a low level of natural bias is not zero bias.

Consider the ensembles created by Dr. Daniel Magleby which he uses to evaluate whether some given plan's mean-median value is (considerably) outside the 95% confidence range generated by the ensemble (see PX 1483). For Congress, Magleby finds the mean-median value in his ensemble to be around 1% more Republican than the statewide average (see Figure 5 in his first Report). A similar 1% pro-Republican bias is found for the Senate (see Figure 4 in his first

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[12] Much of the litigation involving claims involving racial gerrymandering or race as a preponderant motive illustrates this point.

[13] The existence of what has been called "natural bias," has led some commentators to claim that whatever bias is found in a given plan is due to geography, not intent to discriminate. However, as Dr. Duchin correctly points out, the level of natural bias in North Carolina in no way prevents the production of "maps that give the two major parties a roughly equal opportunity to elect their candidates" (PX150, p. 4).

Report), while the pro-Republican bias in the House for the mean-median ensemble is between 2% and 3%.(see Figure 2 in his first Report)

Further evidence of a pro-Republican "natural bias" obtain from simulations that focus on the expected number of seats a party will be expected to get if the partisan vote share is at the historical recent average. Dr. Magleby has done analyses of this kind (see PX1483), but so have other plaintiffs' experts. For example, with a projected 50.8% Republican vote share, while the 10-4 projected vote outcome in the 2022 enacted legislative congressional map is a clear statistical outlier, Dr. Chen finds that a modal congressional outcome in his simulation would have an expected 9 Republican and 5 Democratic seats for the U.S. House (see Report of Dr. Chen PX882, Figure 7, p. 33). Dr. Mageleby's simulation (Figure 6 in his first Report) is similar, with about 8-9 Republican seats.

In sum , so-called "natural bias" tilts the ensembles for the North Carolina upper and lower chambers and for the U.S. House of Representatives somewhat in a pro-Republican direction.[14]

Resting analyses of partisan bias solely on outlier analysis in ensembles creates a two-sided risk. On the one hand, **plans that are highly dilutive might be accepted if the only analysis of equal treatment is an ensemble-based comparison**. **Indeed, <u>if</u> we judge partisan outcomes only by whether they closely match the mean results in an ensemble, we might conclude that, in North Carolina, for both branches of the legislature and for Congress, only at least a somewhat pro-Republican gerrymander is non-dilutive.** [15] On the other hand, any attempt to move toward a truly unbiased map might require moving away from the level of bias that is created by geography, i.e., outside the middle zone of the ensembles, and thus be attacked as a gerrymandering outlier. Such perverse results would, in my view, fly in the face of the North Carolina Supreme Court's assertion that "We hold that our constitution's Declaration of Rights guarantees the equal power of each person's voice in our government through voting in elections that matter" (slip op. p.1).

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[14] As best I can judge all the ensembles created by plaintiffs' experts show an expected pro-Republican tilt in partisan effects measures such as mean-median difference.

[15] The ensemble analyses conducted by Plaintiffs experts in *Harper v. Hall* concluded that the enacted maps to be partisan gerrymanders in that these maps were so egregiously gerrymandered that, on multiple indicators, they fell very far outside the ensemble-based expectations of the amount of expected pro-Republican bias even though the computer-generated ensembles were themselves exhibiting a pro-Republican bias (see above). The ensembles-based conclusions that these maps were egregiously gerrymandered in favor of Republicans, combined with the other evidence of intent and examination of how gerrymandering was done in particular areas of the state, combined with the evidence that the extreme level of pro-Republican bias in these plans would continue throughout the decade under realistic scenarios of future changes in statewide vote, thus locking in a permanent Republican majority in both houses of the legislature and in the state's congressional delegation, made it apparent that the plans should have been struck down as unconstitutional once partisan vote dilution was held to be justiciable under North Carolina state law.

Can we specify some threshold value of a metric such as partisan bias or mean-median difference as being required to supports a claim of egregious gerrymandering that rises to the level of unconstitutionality ?

Both the zero baseline approach and the ensemble-based approach still leave open the question of the point at which the accumulated evidence of gerrymandering leads to a conclusion that this gerrymandering rises to a level of unconstitutionality. But there is one question on which I think there would be widespread agreement, namely that a legislative map does not have to be the "best possible map." The mere fact that a better map on multiple criteria exists does not require a court to choose that map over a map that is adopted through legal channels and due process. The Court's role as mapmaker only begins after the challenged map has been found to be unconstitutional and the legislature has forfeited any right to continue to prepare alternative maps. Moreover, if we think about criteria for demonstrating unconstitutional partisan gerrymandering, there probably also would be agreement that (a) the mere fact that the value of on some metric is a statistical outlier is not enough to show a violation, rather there must be evidence of the substantive importance of the discrepancy,[16] and (b) before a finding of a constitutional violation, it would be important to demonstrate that the political effects of a plan are likely to be non-ephemeral.

However, while it might be seen as desirable for courts to clearly set a threshold for what differences from zero for any given metric are *de minimis* with respect to a claim of unconstitutional partisan gerrymandering, there are two reasons to reject such an approach at this time. First, state courts are only recently come to grips with partisan gerrymandering claims brought under state law. There simply has not been time enough for a body of jurisprudence to emerge. Rather, as the Court Opinion in *Harper v. Hall* suggested, courts should strike down egregious examples of partisan gerrymandering. Only in later cases will courts be in a position to set clear "safe harbor" thresholds if they eventually determine, as the U.S. Supreme Court did in the "one person, one vote" cases, that numerical *de minimis* standards were appropriate.[17]

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[16] In the context of redistricting, this would translate as a finding that the consequences of the statistically significant disparate impact involved an expected seat share change of, say, at least one district (though that number might vary with the size of the legislature). For example, in *League of Women Voters v. Pennsylvania* (slip op. p. 128) the Pennsylvania Supreme Court favorably cites to Dr. Jowei Chen's finding that " while his simulated plans [the ensemble] created a range of up to 10 safe Republican districts… , the 2011 [enacted] Plan creates 13 safe Republican districts."

[17] There are multiple statistical measures of malapportionment such as *total deviation*, defined as the sum of the deviation from ideal in the largest district plus the deviation from ideal in the smallest district, and *average deviation*, among others measures (see e.g., Cervas, Jonathan R., and Bernard Grofman. 2021. Legal, political science and economics approaches to measuring malapportionment: The U.S. House, the Senate, and the Electoral College 1790-2010. *Social Sciences Quarterly*. 101(6): 2238-2256), but, after a while, the Supreme Court largely settled on total population deviation as the key metric for OPOV. In the OPOV cases, after dealing with "horribles," The US. Supreme Court eventually adopted a 10% total population deviation safe

Second, ascertaining the level of gerrymandering in a map is harder than ascertaining the degree of malapportionment in a map. Not only are some of the statistical tools, such as ensembles, much more complicated than simple arithmetic but, perhaps even more importantly, there are multiple (but related) metrics and multiple factors to consider, all of which require careful parsing in terms of forging an overall assessment. Thus, I see the early phases of state court partisan gerrymandering litigation employing a "totality of the circumstances approach," even though also relying on the various specific statistical indicators the *Harper v. Hall* opinion highlighted. [18]

III. Preliminary Evaluations from a Political Science Perspective of the New Legislatively-Drawn Maps for Congress, the NC Senate, and the NC House

Below is a table showing, for each of the five proposed plans and for the three previously enacted maps, a variety of metrics: projections of how many Democratic and Republican leaning seats would be expected and how many districts would be competitive (from 45% to 55%) and also, among the competitive seats, what is the relative balance of Democratic and Republican vote shares; the mean-median gap; two standard measures of partisan bias based on symmetry in a seats-votes curve (one based on how much above a 50% vote share the party with diluted votes would need to win a majority of seats, the other based on the seat share a minority party would get if it won 50% of the vote); the efficiency gap; and a composite measure of compactness that incorporates Polsby-Popper and Reock scores. The calculations are provided from a program, Dave's Redistricting App, which can calculate the standard election-based indices of partisan gerrymandering. The political data reflect major statewide races 2016-2020. The metrics used give a historical baseline of 49.4% Democratic two party vote and 50.8% Republican two-party vote.[19]

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harbor for legislative districts – at least absent evidence of discrepancies lacking a legitimate state purpose, but required population deviation as close as practicable to zero for congressional maps. Having read the OPOV cases and gone back to read key academic commentary both just before and just after *Baker v. Carr*, I think it fair to say that nobody could have predicted the final OPOV standards chosen .

[18] *Brnovich v. Democratic National Committee* 594 U.S. ___ (2021) makes it clear that, in federal jurisprudence, in the context of Section 2 of the Voting Rights Act, a finding of disparate impact is not sufficient, standing alone, to prove a Section 2 violation, since other factors need to be taken into account, the U.S. Supreme Court also asserted "§2 does not transfer the States' authority to set non-discriminatory voting rules to the federal courts." This observation is doubly relevant, in my view, to the present litigation. On the one hand, the Supreme Court recognized the power of the states to set non-discriminatory voting rules. On the other hand, the Supreme Court recognized that no single metric may be enough to prove (or disprove) a constitutional violation, and that contextual analysis is needed.

[19] There is no dispute among experts that, in Dr. Duchin's words, "North Carolina voting has displayed a partisan split staying consistently close to even between the two major

<<Table 1 about here. See below>>

parties over the last ten years." (PX150, p.4).

TABLE 1: Plan Comparisons on Multiple Metrics

Plan Name	Map Type	# of Districts	Rep Districts	Dem Districts	Competive Districts	Mean-Median Dist	Votes Bias	Seats Bias	Efficiency Gap	Compactness
Overturned Congress Plan	Congress	14	8	3	3 (2R, 1D)	5.78%	3.68%	16.86%	17.32%	51
Legislature Congress Plan	Congress	14	6	3	5 (2R, 3D)	0.66%	1.27%	5.27%	6.37%	45
Harper et al. Congress Plan	Congress	14	6	4	4 (1R, 3 D)	0.05%	0.32%	0.93%	1.50%	66
LCV et al. Congress Plan	Congress	14	5	3	6 (1R, 5D)	-1.66%	-0.10%	-0.36%	0.67%	74
Overturned Senate Plan	Senate	50	24	17	9 (5R, 4D)	3.66%	3.31%	7.22%	7.14%	61
Legislature Senate Plan	Senate	50	24	17	9 (4R, 5D)	0.77%	2.02%	4.07%	4.24%	69
Harper et al. Senate Plan	Senate	50	21	19	10 (7R, 3D)	-0.08%	0.48%	1.07%	1.21%	63
LCV et al. Senate Plan	Senate	50	22	17	11 (4R, 7D)	-0.07%	0.72%	1.56%	1.67%	69
Overturned House Plan	House	120	56	40	24 (14R, 10D)	3.61%	2.94%	6.77%	6.71%	65
Legislature House Plan	House	120	54	43	23 (9R,14D)	0.89%	1.29%	2.70%	2.72%	72
LCV et al. House Plan	House	120	55	44	21 (7R, 14D)	1.11%	0.91%	1.69%	1.58%	81

Because lack of constitutionality must be established before any consideration can be given to choosing an alternative map, here I will limit myself to political science perspectives on the constitutionality of each of the legislature's proposed maps. I will not discuss the question of which alternative map should be adopted by the court if the map proposed by the legislature is found to be unconstitutional, except to note that the maps proposed by one or more plaintiffs would seem to be ones that the Court could adopt (perhaps as is, perhaps with very minor modifications) if the corresponding legislative map was struck down. However, while I will not discuss which alternative map is best, since that issue is premature, I will use the alternative maps to show how much closer to zero values on the various metrics it would have been possible to come.

My discussion will be limited to the data presented in Table 1, which reports only metrics calculated at the statewide level.[20] I recognize that the information in this table is not the only relevant material. Thus, my conclusions might be changed upon exposure to expert witness testimony about the various plans. In particular, I am not able to incorporate into my conclusions finding about the maps in terms of the spatial configurations of individual districts or county clusters and how those might have been manipulated For these reasons, I have labeled my Report a Preliminary Report.

Before I turn to the three specific maps proposed by the legislature I should note that, on virtually all statistical metrics, the new plans are significant improvements from the old plans. But the plans previously rejected by the Court were such egregious gerrymanders that the standard of doing better is a very low bar. I would also note that perusal of Figure 4 in 22.2.21 NCLV Plaintiffs' Remedial Comments (at p. 18) suggests that the new proposed congressional map has the most pro-Republican bias of the three proposed maps, and the State House map has the least pro-Republican bias. This is generally consistent with my own findings. Thus, a legal decision about which proposed maps are constitutional/unconstitutional need not be the same for all three maps.

Congress

There are several key facts about the congressional map proposed by the legislature.

First and foremost, in a state that is in recent history one that is nearly evenly divided, it creates a distribution of voting strength across districts that is very lopsidedly Republican: 6 Republican leaning districts that, based on averaged recent data will, barring a political tsunami, elect Republicans; 3 Democratic leaning districts that will, barring a political tsunami, elect Democrats; and 5 competitive districts. A sports analogy may be helpful here. Imagine a playoff series of 14 games of which a majority (9 of 14) have already been played, with five games still to go. The team that has won only 3 of the 9 games would need to win all five of the remaining

[20] I believe the data presented in Table 1 to be a faithful representation of what is found App for the various metrics in Dave's Redistricting, but I recognize that there is always the possibility of error in converting shape files from one GIS program to another and always the possibility of typographical error in my entering data into this Report.

games in order to win the series, and it would need to win four of the five just to get a tie. If the teams were evenly matched in the remaining games of the series the likelihood of winning all five is under 5%.[21] Of course, we need to examine much more closely the expected degree of competition in the districts that DRA labels competitive districts in the proposed congressional map. While there is an apparent Democratic 3-2 advantage in the competitive seats, a close look at the data shows that in 2 of the 3 competitive seats showing a mean Democratic edge that edge is razor thin, and smaller than the still narrow pro-Republican edge in the two Republican leaning competitive districts, while the 3rd district labeled as competitive has a substantial Democratic edge and is a very heavily African-American district Looking at vote margins more closely, we might thus view this map as {6R, 4D, 4 very competitive}.[22] But even so, Democrats would still have to win four of the four competitive seats to win a majority in the delegation.

Second, while the results in the median district look a lot like the statewide average, but with a slight Republican edge, the median is only one district and we must look at the overall map. Here the 5.27% seats bias suggest a substantial pro-Republican bias in terms of the likelihood that a majority of the voters will be able to win a majority of the seats, and the 1.27% vote bias suggests that only a win by more than 50% of the statewide vote can yield the Democrats a majority of the seats. When we compare these levels of partisan bias to the level of partisan bias in the Harper and NCLCV maps we see that each of these two bias measures is multiple times higher in the legislative map than in the alternatives and, even when we look at differences in absolute value rather than ratios, it is still clear that the legislatively proposed congressional map is much more extreme with respect to partisan bias.

Third, the level of compactness of the districts in the previous map was a statistical outlier relative to the ensembles (Chen Expert Report PX482, pp. 17-19) and since the DRA compactness score the new congressional map proposed by the legislature is even lower, my expectation is that, with respect to district compactness the new map will also be a clear statistical outlier. However, unlike its predecessor (Chen Expert Report PX482, Figure 1, p. 14), doing a visual check, the new congressional map does not appear to split any counties in more than two pieces.

Fourth, there has been a substantial drop in the efficiency gap in the new map as compared to the congressional map found to be unconstitutional. But the efficiency gap is not directly a test for

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[21] Of course, this is an improved situation for the Democrats compared to the enacted congressional map, since that map (8 Rep, 3 Dem, 3 competitive) in effect said that the outcome was foreordained before the last three games were played. Barring a political tsunami, that map locked in a permanent Republican majority, and it was shown in the expert witness testimony to make a 10R-4D outcome very likely. Of course, that map was also one of the handful of most blatant and egregious partisan gerrymanders in the nation.

[22] Note that to do this exactly we would need to look election by election to see how often Democrats won, since the mean vote share averaged across elections can lead to misleading conclusions because of variation in Democratic performance. See discussion of essentially this point in Dr. Duchin's Rebuttal Expert Witness Report (PX234).

bias; rather it measures, roughly speaking, how far from a responsiveness level of 2 a map implements. As Dr. Duchin has argued in her previous work, in a view that I share, high values of the efficiency gap are a sign that something may be seriously wrong and signal a need to investigate carefully. However, in my view, low values of the efficiency gap, are not a proof that there is no vote dilution. By offering a map with an efficiency gap of 6.37% for their congressional map, i.e., one with an efficiency gap below 7, the legislative map drawers have apparently sought to draw a congressional map that just narrowly pass a supposed threshold test for partisan gerrymandering (see Memorandum on Remedial Process 4876-1419-931, at p. 7). And the efficiency gap is still a result in a pro-Republican direction.

Because they all point in the same direction, the political effects statistical indicators of partisan gerrymandering strongly suggest the conclusion that this congressional map should be viewed as a pro-Republican gerrymander, but whether these gerrymandering effect rises to the level of a constitutional violation must, of course, be left to legal determination. On the other hand, if I am correct that the compactness of the districts is at a level to show proof of severe outlier status, that in and of itself may be sufficient reason to reject the plan. But of course, that again is entirely a legal question up to the Court to resolve.

NC Senate

My analysis and conclusions for the legislatively proposed NC Senate map are similar to those for legislatively proposed congressional map. In a state that is in recent history one that is nearly evenly divided, this map, too, creates a distribution of voting strength across districts that is very lopsidedly Republican: 24 Republican leaning districts that, based on averaged recent data will, barring a political tsunami, elect Republicans; 17 Democratic leaning districts that will, barring a political tsunami, elect Democrats; and 5 competitive districts. Democrats would have to win nine of the nine competitive seats to win a majority in the Senate.

Second, while the median district again looks a lot like the statewide average, but again with a slight Republican edge, the median is only one district and we must look at the overall map. Here the 4.07% seats bias still suggest a substantial pro-Republican bias in terms of the likelihood that a majority of the voters will be able to win a majority of the seats, even though it is one percentage point or so lower than the comparable statistic in the congressional map, while the 2.00 % vote bias suggests that only a win by considerably more than 50% of the statewide vote can yield the Democrats a majority of the seats. Indeed, on this metric the new NC Senate map is more extreme by nearly a percentage point than the new NC House map. When we compare these levels of partisan bias to the level of partisan bias in the Harper and NCLCV maps we see that each of these two bias measures is at least twice as high in the legislative map as in the alternatives and, even when we look at differences in absolute value rather than ratios, it is still clear that the legislatively proposed congressional map is much more extreme with respect to partisan bias than either of the alternatives.

Third, the compactness level in the Senate map is comparable or higher than that in the alternative Senate maps.

Fourth, there has been a substantial drop in the efficiency gap in the new map as compared to the congressional map found to be unconstitutional. But it remains in a pro-Republican direction.

Because they all point in the same direction, the political effects statistical indicators of partisan gerrymandering argue for the conclusion that this NC Senate map should be viewed as a pro-Republican gerrymander. While, overall, the dilutive effects of this map do not appear quite as severe as in the congressional map they are still still quite substantial. However, I have not had time to analyze how the map may have been manipulated at the level of individual districts in terms of things like city cuts or county transversals. Of course, whether the clear indicators of partisan gerrymandering effects identified in Table 1 and my discussion rise to the level of a constitutional violation requires determination by this Court.

NC State House

My analysis for the legislatively proposed NC House map uses the same approach as for the previously considered maps. In a state that is in recent history one that is nearly evenly divided, this map, too, creates a distribution of voting strength across districts that is very lopsidedly Republican: 54 Republican leaning districts that, based on averaged recent data will, barring a political tsunami, elect Republicans; 43 Democratic leaning districts that will, barring a political tsunami, elect Democrats; and 23 competitive districts. In the House, however, unlike the other maps, the Democrats do not have to win all of the competitive seats to win a majority in the House. Moreover, unlike the other two proposed maps, when we look at the proposed NC House map we see that the competitive seats are substantially Democrat in directionality (9R, 14D). This map is genuinely far more competitive than either of the other two legislatively proposed maps even though (see below) it remains tilted in a pro-Republican direction.

Second, while the median district again looks a lot like the statewide average, but again with a slight Republican edge, the 2.70% seats bias still suggest a substantial pro-Republican bias in terms of the likelihood that a majority of the voters will be able to win a majority of the seats. But the value on this metric is one which is more than one percentage point lower than the comparable statistic in the Senate map, and the 1.29% vote bias in this map is again almost one percentage point lower than the 2.00 value of this metric for the Senate. But arguably quit important in judging the constitutionality of this map in the full context are the facts that: (a) the Harper plaintiffs have not chosen to offer an alternative NC House map but are apparently content to see the legislative map implemented by the Court, (b) the map was passed by a clear bipartisan consensus in the legislature, including members of the legislature who belong to particular minority communities, and (c) that while it still is further from being non-dilutive than the NCLCV House map alternative, it is far closer to Plaintiffs' map than it is to the rejected enacted NC House map.

Third, the compactness level in the Senate map is high relative to the other maps in Table 1, even though the NCLCV House map alternative has an even higher score.

Fourth, there has been a substantial drop in the efficiency gap in the new map as compared to the NC House map found to be unconstitutional. It is at the low level of 2.72 even though it remains in a pro-Republican direction.

I have not had time to analyze how this map may have been manipulated at the level of individual districts in terms of things like city cuts or county transversals or racial fragmentaion. But of the three legislatively proposed maps, for the reasons given above, this is the one that I would feel most comfortable with seeing ordered by the Court. Looking at the totality of the circumstances insofar as these are presently known to me, and recognizing that this map is still not ideal (nor need it be), this legislatively proposed NC House map simply lacks the same clear indicia of egregious bias found in the previously rejected maps and still found, but to a lesser extent than in the rejected maps, in the legislatively proposed maps for Congress and for the NC Senate that I discuss above.

STATE OF NORTH CAROLINA

COUNTY OF WAKE

IN THE GENERAL COURT OF JUSTICE
SUPERIOR COURT DIVISION
No. 21 CVS 015426

NORTH CAROLINA LEAGUE OF CONSERVATION VOTERS, INC., *et al.*,

Plaintiffs,

COMMON CAUSE,

Plaintiff-Intervenor,

v.

REPRESENTATIVE DESTIN HALL, in his official capacity as Chair of the House Standing Committee on Redistricting, *et al.*,

Defendants.

STATE OF NORTH CAROLINA

COUNTY OF WAKE

IN THE GENERAL COURT OF JUSTICE
SUPERIOR COURT DIVISION
No. 21 CVS 500085

REBECCA HARPER, *et al.*,

Plaintiffs,

v.

REPRESENTATIVE DESTIN HALL, in his official capacity as Chair of the House Standing Committee on Redistricting, *et al.*,

Defendants.

HARPER PLAINTIFFS' RESPONSE TO LEGISLATIVE DEFENDANTS' PROPOSED REMEDIAL MAPS

It is now the law of this State that North Carolina's redistricting plans must give "voters of all political parties substantially equal opportunity to translate votes into seats across the plan." *Harper v. Hall*, No. 413PA21, Order ¶ 6 (N.C. Feb. 4, 2022). In particular, "voters are entitled to have substantially the same opportunity to elect[] a supermajority or majority of

representatives as the voters of the opposing party would be afforded if they comprised" a given percentage "of the statewide vote share in that same election." *Harper v. Hall*, No. 413PA21, slip op. ¶ 169 (N.C. Feb. 14, 2022). "What matters here, as in the one-person, one-vote context, is that each voter's vote carries roughly the same weight when drawing a redistricting plan that translates votes into seats in the legislative body." *Id.*

Legislative Defendants' proposed remedial congressional and Senate plans flout the Supreme Court's order and opinion. They do not provide voters of both parties remotely equal opportunity to elect representatives. Rather, their proposed remedial plans fail several key measures of partisan symmetry—and are substantially worse than the remedial plans *Harper* Plaintiffs have proposed. Legislative Defendants' own expert, Dr. Barber, shows Legislative Defendants' proposed plans to be Republican gerrymanders.

These skewed results are not surprising. The congressional and Senate plans enacted by the General Assembly last week were forced through the committees and passed on strict party-line votes in both chambers. These proposed plans replicate central unconstitutional features of the now-invalidated plans. For example, this Court found that the 2021 congressional plan's "creation of three safe Republican districts in the Piedmont Triad area"—by placing Greensboro, High Point, and Winston-Salem in separate districts—was "designed in order to accomplish the legislature's predominant partisan goals." Judgment, FOF ¶¶ 473, 480. Yet Legislative Defendants' proposed remedial congressional plan does *the same thing*. And Legislative Defendants' Senate plan recreates the splitting of voters in Wilmington that the three-judge panel found unconstitutional in *Common Cause v. Lewis*, No. 18 CVS 014001, 2019 WL 4569584, at *53 (N.C. Super. Sep. 03, 2019).

This Court should reject Legislative Defendants' unconstitutional congressional and Senate plans and should instead adopt *Harper* Plaintiffs' proposed plans, which are superior on every metric the Supreme Court identified and would afford voters of both parties an equal opportunity to translate votes into seats.

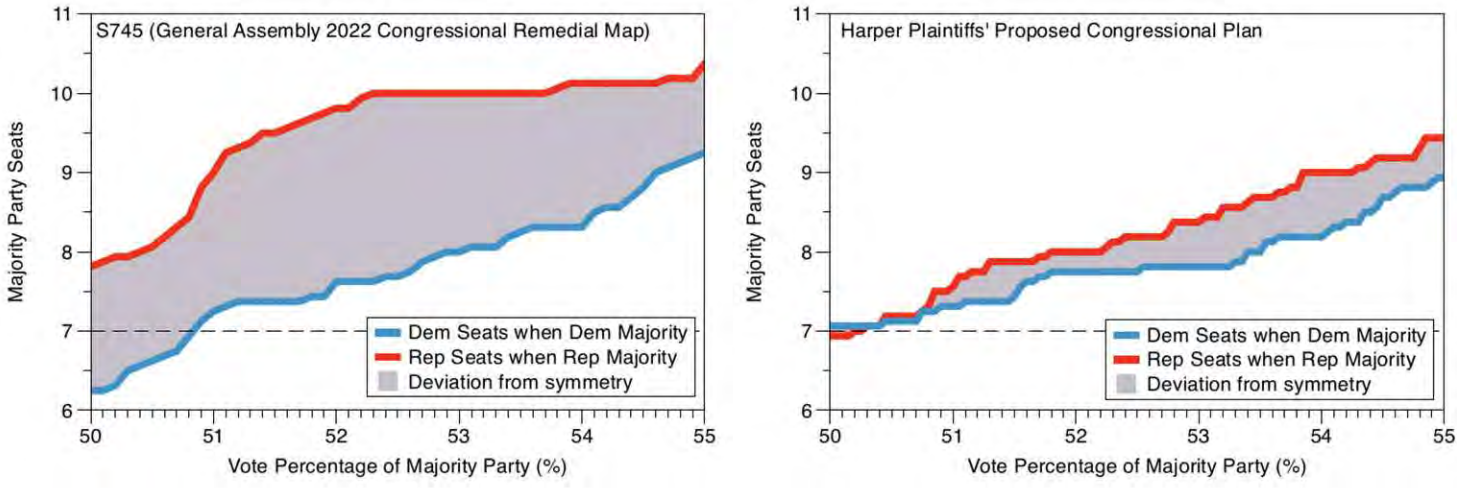
I. Legislative Defendants' Proposed Remedial Congressional Plan Is Unconstitutional

Legislative Defendants' plan does not provide voters substantially equal voting power.

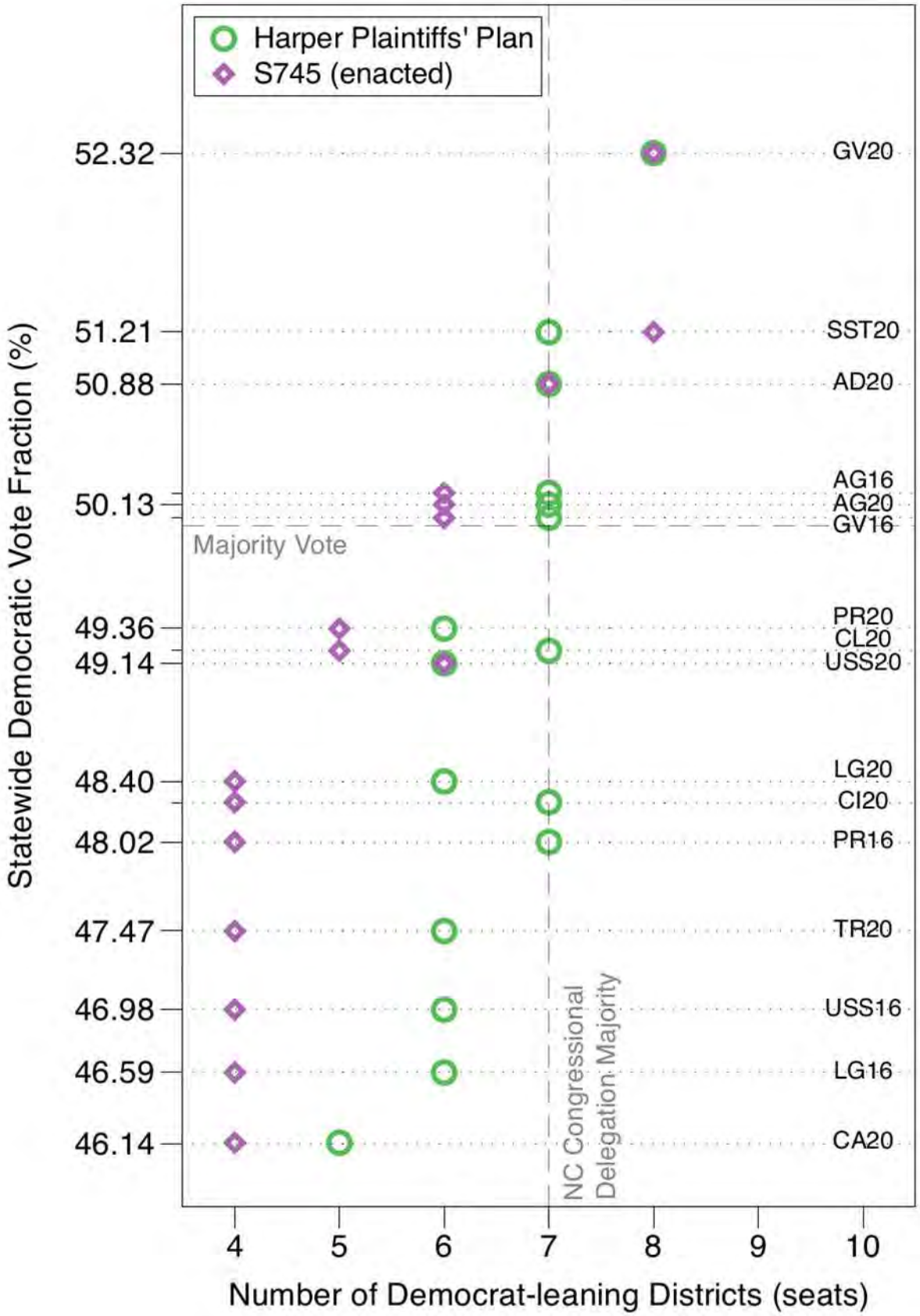
Legislative Defendants' proposed congressional plan, S.B. 745, fails on the key measures that the Supreme Court identified as dispositive. For starters, the Supreme Court repeatedly emphasized that "partisan symmetry" is essential to ensuring that all voters have substantially equal voting power. Order ¶ 5; slip op. ¶ 4. Requiring a "substantially equal opportunity to translate votes into seats across the plan," slip op. ¶ 163, is the essence of partisan symmetry analysis. Accordingly, Dr. Jonathan Mattingly and his Duke colleague Dr. Gregory Herschlag in their report submitted with this response measured the partisan symmetry of S.B. 745 using the same metric described in *Harper* Plaintiffs' written submission regarding their own proposed plans. *See Harper* Pls.' Feb. 18, 2022 Stmt. 4-6; Mattingly-Herschlag Remedial Rep. 2-3. This partisan-symmetry metric measures the *absolute deviation* between the number of seats that the two parties are expected to elect at the same given vote share, calculated based on the results of 16 recent statewide elections applying a variety of "uniform swings." Mattingly-Herschlag Remedial Rep. 2-3. Legislative Defendants' expert Dr. Michael Barber endorses this approach to evaluating partisan symmetry: "The basic idea is to look at the vote share in each district and increase/decrease the vote share in each district by a uniform amount across a range of outcomes," and "as Democrats gain more votes statewide, the translation of those votes to seats should be similar to when Republicans gain an equally large share of the votes." Barber Remedial Rep. 17-18.

For S.B. 745, the symmetry deviation is **1.575 seats**. Mattingly-Herschlag Remedial Rep. 3. Thus, for any given statewide election, the difference between the number of Democratic and Republican seats elected at the same respective party vote fraction will more often than not be ***2 seats*** of only 14 total seats available. *Id.* This is *an extreme asymmetry*. And nothing in North Carolina's political geography requires it. If Legislative Defendants had simply picked 20 plans at random from Dr. Mattingly's ensemble—which was not even designed with partisan symmetry in mind—there is a 99.998% chance they would have found a plan with better partisan symmetry than S.B. 745. *Id.* In sharp contrast, *Harper* Plaintiffs' proposed congressional plan shows a deviation of only **0.36875 seats**; meaning that for any given statewide election, the number of Democratic and Republican seats elected at a given vote fraction will typically be the same. *Id.*

Figure 2 from Dr. Mattingly and Dr. Herschlag's report illustrates the huge partisan asymmetry in S.B. 745, with the red line showing the average number of expected seats when Republicans win a particular vote share, and the blue line showing the same figure for Democrats when they win the same vote share. *Id.* at 4. To produce these figures Drs. Mattingly and Herschlag conducted a partisan swing analysis for all 16 statewide elections in 2016 and 2020, then calculated the average seat share for each party at different vote shares. *Id.* at 3-4. The contrast between S.B. 745 and *Harper* Plaintiffs' proposed remedial congressional plan is stark, particularly for the closer, frequently occurring vote shares near 50%:



The asymmetry in S.B. 745 is also clear based on raw expected seats for both parties under various historical elections. As Figure 1 from the Mattingly-Herschlag report shows using purple markers, in half (3 of 6) of the statewide elections in 2016 and 2020 where the Democrats won a majority of the vote (AG16, AG20, and GV20), they still win only 6 seats (a minority) under S.B. 745. But there is not a single election where the Republicans win a majority of votes but a minority of seats. As another example, under the 2016 Presidential election, where Democrats won 48% of the vote, Democrats win only 4 seats under S.B. 745. Yet under the 2020 Governor election, where Republicans won just over 48% of the vote, Republicans win 6 seats. This significant, inescapable asymmetry affects real seats across a range of elections. By contrast, with *Harper* Plaintiffs' proposed plan (as shown with green markers), the party with a majority of votes wins at least half the seats in every single election.

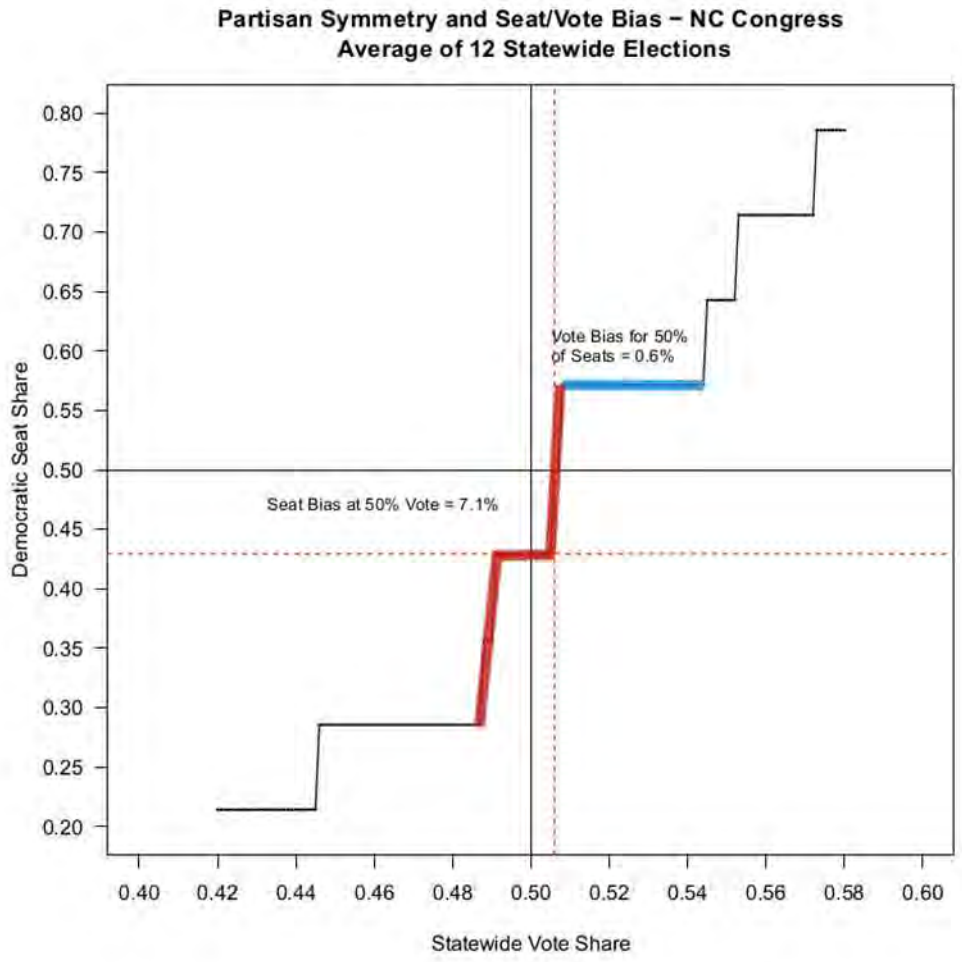

Harper Plaintiffs' Plan
S745 (enacted)
52.32
51.21
50.88
50.13
49.36
49.14
48.40
48.02
47.47
46.98
46.59
46.14
GV20
SST20
AD20
AG16
AG20
GV16
PR20
CL20
USS20
LG20
CI20
PR16
TR20
USS16
LG16
CA20
Majority Vote
NC Congressional Delegation: Majority
Statewide Democratic Vote Fraction (%)
4
5
6
7
8
9
10
Number of Democrat-leaning Districts (seats)

Legislative Defendants' proposed congressional plan also fails two other metrics the Supreme Court identified as significant: the mean-median difference and the efficiency gap. Legislative Defendants' plan has an average efficiency gap of 7.312% (calculated by conducting uniform swings on the 16 historical election results), which is above the 7% threshold of presumptive constitutionality identified by the Supreme Court. Mattingly-Herschlag Rep. 3; *see* *Harper*, slip op. ¶ 167. And Legislative Defendants' mean-median difference is 1.01%, which exceeds the 1% threshold identified by the Supreme Court. Mattingly-Herschlag Rep. 3; *see* *Harper*, slip op. ¶ 166. By comparison, *Harper* Plaintiffs' proposed congressional plan has an efficiency gap of less than 3% and a mean-median difference of 0.4504%, well within the Supreme Court's thresholds. Mattingly-Herschlag Rep. 3. Even accounting for the difference that choices of election can make, Dr. Barber's efficiency gap and mean-median difference calculations for the Legislative Defendants' congressional plan are *simply wrong*. The publicly available website PlanScore reports a mean-median gap of 1.1% favoring Republicans and an efficiency gap of 6.4% favoring Republicans for S.B. 745.

Dr. Barber's results show that S.B. 745 fails partisan symmetry. Dr. Barber's own partisan symmetry analysis, in his Figure 3(b), shows that S.B. 745 dramatically favors Republicans in their ability to translate increasing vote shares into increased seat counts. As shown below using blue highlighting on Dr. Barber's Figure 3(b), Dr. Barber concludes that even when Democrats increase their vote share from approximately 50.6% to nearly 55%—in North Carolina, a landslide—they still can win only eight congressional seats. By contrast, as shown using red highlighting, Republicans, by increasing their vote share from merely 49.4% to approximately 51% gain an 8th, 9th, and even *10th* seat. In other words, even under Dr. Barber's analysis, Democrats can gain nearly 4.5% vote share (to a whopping 55%) without gaining even

one additional seat (and even then win only 8 total); whereas Republicans need only an increase of approximately 1.6% vote share to gain *three additional seats* (and 10 total). Clearly, Legislative Defendants' plan does not give voters from both political parties "substantially the same opportunity" to elect representatives at a given percentage "of the statewide vote share in that same election." *Harper*, slip op. ¶ 169.

(b) 2022 Remedial plan



Dr. Barber's "close-votes-close-seats analysis" is even more damning. Barber Remedial Rep. 16. Dr. Barber uses a four-square plot (Figure 2) to show which recent statewide election results would produce a "majoritarian outcome" (where the party with a majority vote share wins a majority of seats) versus an "antimajoritarian outcome" (where a majority of votes does not

yield a majority of seats). His plot shows only one election that produces an antimajoritarian outcome: the 2016 Attorney General race, where Democrats won over a majority of votes but would get only 6 seats under Legislative Defendants' map.

But Dr. Barber's analysis selectively excluded four recent statewide elections—*two* of which (2016 Governor and 2016 Attorney General) are antimajoritarian. No surprise, both of these excluded antimajoritarian elections disfavor the Democrats. As shown in Table 1 from the Mattingly-Herschlag report, once Dr. Barber's selectively deleted elections are added back in, his analysis shows that in fully half (3 of 6) of the statewide elections in 2016 and 2020 where the Democrats won a majority of the vote, they still win 6 seats (a minority) under S.B. 745.[1] By comparison, under *Harper* Plaintiffs' proposed plan, the party who wins the majority of the vote wins at least 50% of the seats every single time.

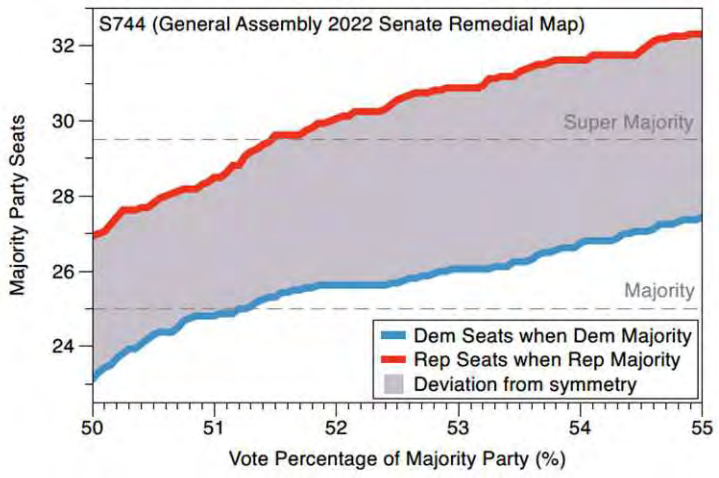
Democratic Elections						Republican Elections					
		S745 (Cong.)		Plaintiffs' Cong.				S745 (Cong.)		Plaintiffs' Cong.	
Election	Democratic Vote (%)	Dem. Seats	Dem. Split or Won Majority	Dem. Seats	Dem. Split or Won Majority	Election	Republican Vote (%)	Rep. Seats	Rep. Split or Won Majority	Rep. Seats	Rep. Split or Won Majority
GV16	50.05	6	No	7	Yes	PR20	50.64	9	Yes	8	Yes
AG20	50.13	6	No	7	Yes	CL20	50.78	9	Yes	7	Yes
AG16	50.20	6	No	7	Yes	USS 20	50.86	8	Yes	8	Yes
AD20	50.88	7	Yes	7	Yes	LG20	51.60	10	Yes	8	Yes
SST20	51.21	8	Yes	7	Yes	CI20	51.73	10	Yes	7	Yes
GV20	52.32	8	Yes	8	Yes	PR16	51.98	10	Yes	7	Yes
						TR20	52.53	10	Yes	8	Yes
						USS 16	53.02	10	Yes	8	Yes
						LG16	53.41	10	Yes	8	Yes
						CA20	53.85	10	Yes	9	Yes

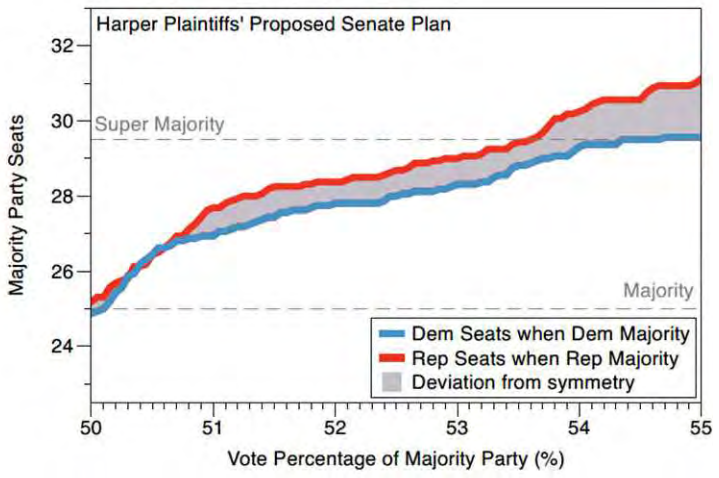
[1] Dr. Barber suggests that he selectively excluded these 4 elections because Dr. Mattingly's merits-phase report did. That is wrong. Dr. Mattingly analyzed the 2021 congressional map using all 16 2016 and 2020 statewide elections, *see* Mattingly Rep. 75-76, 95-97, and all of his statewide analysis for the state Senate and House plans used those same 16 elections, *id.* at 11, 19, 22, 28.

II. Legislative Defendants' Proposed Remedial Senate Plan Is Unconstitutional

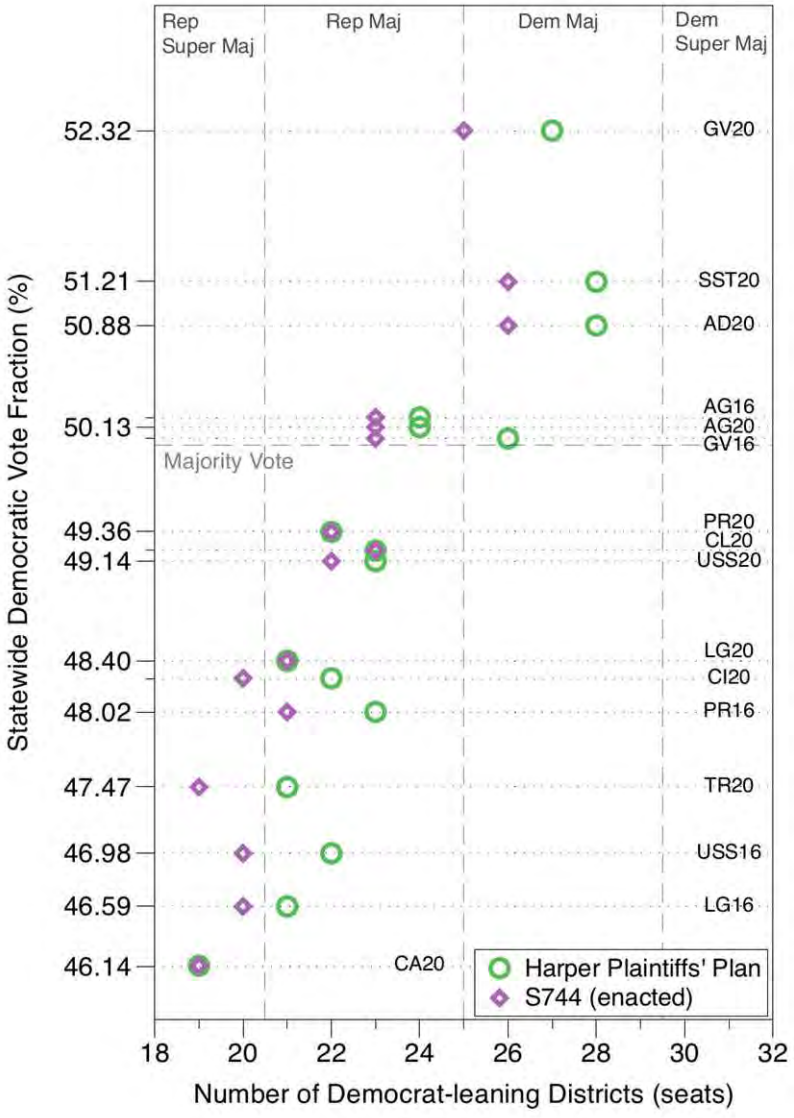
Legislative Defendants' Senate plan does not provide voters substantially equal voting power. *Harper* Plaintiffs' proposed Senate plan produced an average deviation in seats won at a given party vote share of only **1.04375 seats**. The deviation in Legislative Defendants' plan is nearly quadruple that: **4.0125** seats. If Legislative Defendants had selected *even a single random plan* from Dr. Mattingly's ensemble—which again was not drawn to prioritize partisan symmetry in any way—that plan would have had better partisan symmetry than S.B. 744 with **99.6%** probability. Mattingly-Herschlag Rep. 6.

And as with the congressional plan, this asymmetry is significant across election outcomes, as shown in Figure 4 from the Mattingly-Herschlag report, which shows the number of seats for each party that are expected at the same vote share in S.B. 744 and in *Harper* Plaintiffs' proposed Senate plan, using uniform swing analysis. Once again, the contrast is stark; it shows that S.B. 744 isn't even trying to ensure that the parties have a substantially equal opportunity to translate votes into seats:





Seat counts under historical elections confirm S.B. 744's extreme asymmetry. Figure 3 from the Mattingly-Herschlag report shows that—just like with the congressional plan—Democrats win a minority of seats in *half* the elections where they won a majority of the vote. Yet again, this antidemocratic result is not symmetrical: there isn't a single election where the Republicans win a majority of votes but a minority of seats. The asymmetry also protects Republican supermajorities: When Democrats win 51.21% of the vote under the 2020 Secretary of State election, they barely win a majority of seats. Meanwhile, when Republicans get a similar vote share under the 2020 Commissioner of Insurance election, they win a safe supermajority:

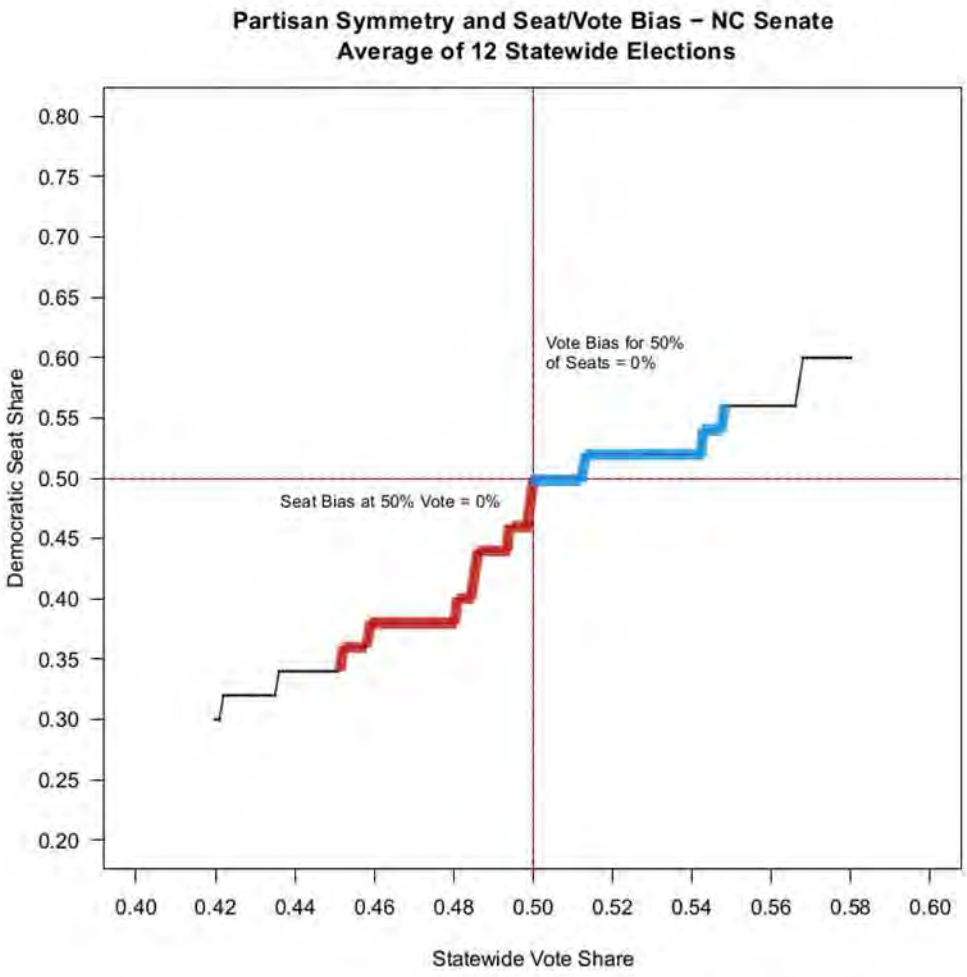


Legislative Defendants' proposed Senate plan also fails the 1% mean-median threshold identified by the Supreme Court as presumptively constitutional, with a mean-median difference of 1.304%. Mattingly-Herschlag Remedial Rep. 6. As with the proposed congressional plan, Dr. Barber's mean-median calculation here (of 0.61%) is wrong: The public website PlanScore reports a 2.2% difference favoring Republicans for S.B. 744.[2] By comparison, *Harper* Plaintiffs' proposed Senate plan has a mean-median difference of 0.228% and an efficiency gap of less than 2%. Mattingly-Herschlag Remedial Rep. 6.

Dr. Barber's analysis confirms that S.B. 744 fails partisan symmetry. As with Legislative Defendants' proposed congressional plan, Dr. Barber's analysis confirms the lack of partisan symmetry in their Senate plan. As shown in Dr. Barber's Figure 9(b), highlighted in red and blue below, Democrats need dramatic increases in vote share to produce additional seats and have effectively no chance at winning a supermajority even at unprecedented vote shares. For example, Democrats must ascend from 50% vote share to nearly 55% vote share before gaining a 28th seat, and are still 2 seats short of a supermajority. If Republicans experience that same 5-point increase from 50% to 55%, their seat count jumps to 33 seats—well over a supermajority.

[2] https://planscore.campaignlegal.org/plan.html?20220218T174649.330672091Z

(b) 2022 Remedial plan



III. Ensemble Comparisons, While Inappropriate, Confirm That Legislative Defendants' Plans Are Gerrymanders

The ensemble analysis presented to this Court at trial established that the 2021 maps were partisan gerrymanders. But the North Carolina Supreme Court's ruling has made clear that the question is no longer simply whether a given map compares favorably with an ensemble of randomly generated plans. None of Plaintiffs' experts simulated plans were designed to maximize partisan fairness or symmetry, and performing at the median of a random sample of maps that were *not* designed to maximize partisan fairness would not necessarily show that voters are being treated fairly and equally. Rather, North Carolina's Constitution requires

mapmakers to affirmatively draw maps to secure partisan symmetry, unless partisan symmetry is not possible while preserving counties, ensuring equal population, and drawing compact maps. As *Harper* Plaintiffs' proposed Congressional and Senate map shows, it is easy to draw maps that show a high degree of partisan symmetry without sacrificing any of those objectives and while protecting incumbents.

But the General Assembly's remedial maps are outliers even under ensemble analysis. For example, S.B. 744 still gives Republicans a Senate supermajority when they get just under 48.4% of the statewide vote, a result that almost never occurred in Dr. Mattingly's ensemble. Mattingly Rep. 28. And S.B. 744 still gives Republicans a majority even when Democrats win 52.32% of the statewide vote, also a result that almost never occurred in Dr. Mattingly's ensemble. Mattingly Rep. 28. (The proper comparison is to Dr. Mattingly's secondary Senate ensemble that did not minimize municipality splits, because the Supreme Court did not identify municipality preservation as a principle that could justify partisan asymmetries.)

Likewise, S.B. 745 still guarantees a 10-4 split favoring Republicans unless the Democrats win at least 49% of the statewide vote. Those results are well outside the median range of Dr. Mattingly's congressional ensemble. Mattingly Rep. 74. And as described above, both of the legislature's proposed remedial plans compare poorly to the ensembles on basic measures of partisan symmetry even though the ensembles weren't designed with that in mind. Mattingly-Herschlag Remedial Rep. 3, 6.

IV. The Court Should Address Article II's Residency Requirements

The *NCLCV* Plaintiffs have asked the Court to order that, if any citizen has established his or her residence in a Senate or House district modified by any remedial redistricting plan adopted or approved by this Court, then that citizen shall be qualified to serve if elected, notwithstanding any requirements that Sections 6 and 7 of Article II of the North Carolina

Constitution would otherwise impose. *See* NCLCV Pls.' Cmts. 23-24 (citing *Covington v. North Carolina*, 267 F. Supp. 3d 664, 668 (M.D.N.C. 2017)). *Harper* Plaintiffs join that request.

Respectfully submitted, this the 21st day of February, 2022.

By:/s/ Narendra K. Ghosh

PATTERSON HARKAVY LLP

Burton Craige, NC Bar No. 9180
Narendra K. Ghosh, NC Bar No. 37649
Paul E. Smith, NC Bar No. 45014
100 Europa Dr., Suite 420
Chapel Hill, NC 27517
(919) 942-5200
bcraige@pathlaw.com
nghosh@pathlaw.com
psmith@pathlaw.com

Counsel for Harper Plaintiffs

ELIAS LAW GROUP LLP

Abha Khanna*
1700 Seventh Avenue, Suite 2100
Seattle, Washington 98101
Phone: (206) 656-0177
Facsimile: (206) 656-0180
AKhanna@elias.law

Lalitha D. Madduri*
Jacob D. Shelly*
Graham W. White*
10 G Street NE, Suite 600
Washington, D.C. 20002
Phone: (202) 968-4490
Facsimile: (202) 968-4498
LMadduri@elias.law
JShelly@elias.law
GWhite@elias.law

ARNOLD AND PORTER KAYE SCHOLER LLP

Elisabeth S. Theodore*
R. Stanton Jones*
Samuel F. Callahan*
601 Massachusetts Avenue NW
Washington, DC 20001-3743
(202) 954-5000
elisabeth.theodore@arnoldporter.com

Counsel for Harper Plaintiffs
* Admitted Pro Hac Vice

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a copy of the foregoing *by email*, addressed to counsel for all other parties.

This the 21st day of February, 2022.

_/s/ Narendra K. Ghosh _____
Narendra K. Ghosh, NC Bar No. 37649

Remedial Report : Congressional and NC Senate Plans

Greg Herschlag and Jonathan C. Mattingly

February 21, 2022

1 Introduction and summary

We have been asked by the Harper Plaintiffs and the Common Cause Plaintiffs to analyze two redistricting maps for both the North Carolina Congressional districts and the North Carolina Senate districts. Specifically, we will examine the Congressional and Senate maps that were recently passed by the General Assembly in laws 2022-3 (Congressional, S745), 2022-2 (Senate, S744), as well as alternative maps put forward by the Harper plaintiffs. The comments and analysis addressing the Harper Plaintiffs' proposed map were done solely at the request of the Harper Plaintiffs and not by the Common Cause Plaintiffs.

Because of the language in the court ruling, our primary tool of analysis is to examine partisan symmetry, which is the idea that a specific vote share should translate into a specific seat share, independent of which party received that vote.[1] The exact translation of votes to seats need not be known ahead of time; the important aspect of symmetry is that the translation is the same for both parties. As one example, under a map that has partisan symmetry, if the Republicans receive 55% of the vote and 70% of the seats, then when the Democrats receive 55%, they will also receive 70% of the seats. Prioritizing symmetry does not translate into any proportionality standard. However under a symmetric map, the party that wins the majority of the vote should win the majority of the seats (or at least not be in the minority).

The Supreme Court's order also mentioned other metrics that can give some insight into the symmetry properties (as well as other properties) of a map, including the mean-median difference and the efficiency gap. We prefer to report directly on measures of partisan symmetry and focus on those in this report, but we also report mean-median difference and efficiency gaps.

We examine partisan symmetry characteristics of the four maps under 16 historic elections from 2016 and 2020: 2016 Attorney General, 2016 Governor, 2016 Lieutenant Governor, 2016 Presidential, 2016 U.S. Senate, 2020 State Auditor, 2020 Attorney General, 2020 Commissioner of Agriculture, 2020 Commissioner of Insurance, 2020 Commissioner of Labor, 2020 Governor, 2020 Lieutenant Governor, 2020 Presidential, 2020 Secretary of State, 2020 Treasurer, and 2020 U.S. Senate.

We find that the plaintiff maps show significantly greater amounts of symmetry than the recently passed maps put forward by the North Carolina legislature. We also demonstrate that if twenty maps were drawn from our original ensemble, which was constructed without regard to partisan symmetry, it would be extremely likely to find a map with significantly superior partisan symmetry when compared with the legislature's enacted remedial maps. In other words, even drawing maps at random, it is not difficult to draw maps that achieve significantly better partisan symmetry than the legislature's proposed remedial maps.

2 Qualifications

We are Professors of Mathematics at Duke University. Dr. Mattingly is also a Professor of Statistical Science at Duke University. His degrees are from the North Carolina School of Science and Math (High School Diploma), Yale University (B.S.), and Princeton University (Ph.D.). He grew up in Charlotte, North Carolina, and currently lives in Durham, North Carolina. Dr. Herschlag's degrees are from Taylor Allderdice (High School Diploma), University of Chicago (B.S.), and the University of North Carolina at Chapel Hill (Ph.D.). He has lived in North Carolina since 2007.

Both of us lead a group at Duke University that conducts non-partisan research to understand and quantify gerrymandering. This report grows out of aspects of our group's work around the current North Carolina legislative districts which are relevant to the case being filed.

Dr. Mattingly previously submitted an expert report in Common Cause v. Rucho, No. 18-CV-1026 (M.D.N.C.), Diamond v. Torres, No. 17-CV-5054 (E.D. Pa.), Common Cause v. Lewis (N.C. Sup. Ct No. 18-cvs-014001), and Harper v. Lewis

(No. 19-cv-012667) and was an expert witness for the plaintiffs in Common Cause v Rucho and Common Cause v. Lewis. Dr. Herschlag previously submitted an affidavit in North Carolina v. Covington, No. 1:15-cv-00399. We are being paid at a rate of $400/per hour for this work. Much of the work, including the randomly generated maps, derives from an independent research effort, unrelated to this lawsuit, to understand gerrymandering nationally and in North Carolina specifically. Some of the analysis described in this report was previously released publicly as part of a non-partisan effort to inform the discussion around the redistricting process.

3 Methods

We evaluate the proposed plans using a partisan symmetry metric described below. We also report the the mean-median difference and the efficiency gap. Each of these metrics was calculated using the results of sixteen recent statewide elections: 2016 Attorney General, 2016 Governor, 2016 Lieutenant Governor, 2016 Presidential, 2016 U.S. Senate, 2020 State Auditor, 2020 Attorney General, 2020 Commissioner of Agriculture, 2020 Commissioner of Insurance, 2020 Commissioner of Labor, 2020 Governor, 2020 Lieutenant Governor, 2020 Presidential, 2020 Secretary of State, 2020 Treasurer, and 2020 U.S. Senate. In many analyses, we also consider the uniform swing of the elections under consideration which allows us to consider a varied range of statewide partisan vote fractions over multiple plausible voting patterns.

In line with the classic definition of partisan symmetry, the North Carolina Supreme Court explained, "voters are entitled to have substantially the same opportunity to electing a supermajority or majority of representatives as the voters of the opposing party would be afforded if they comprised" a given percentage "of the statewide vote share in that same election." Harper v. Hall, No. 413PA21, slip op. ¶169 (N.C. Feb. 14, 2022). To implement this directive, we measure the partisan symmetry by calculating the number of seats awarded to the party winning the majority of votes in pairs of elections that have total statewide partisan vote shares which are symmetric about the 50% level. Examples of symmetric pairs are 49% and 51% or 48% and 52%. We then report the absolute difference in the number of seats awarded. If both parties were treated symmetrically, this difference would be zero.

To take an example: we begin with the results of the 2016 Governor election and apply a "uniform swing" to reflect a 48% Democratic statewide vote share for that election. We calculate how many Republican representatives would be elected with this 48% Democratic vote share. We then apply a uniform swing to the election so that it reflects the corresponding, reciprocal Democratic vote share–i.e., 52%. We then compute the number of Democratic representatives that would be elected with that 52% Democratic vote share. We then calculate the absolute difference between the number of Republican representatives elected with 48% Democratic vote share and the number of Democratic representatives elected with a 52% Democratic vote share. Thus, if 8 Republicans were elected with 48% Democratic vote share, and 7 Democrats were elected with 52% vote share, the absolute difference would be 1 seat. (Because the figure is absolute, the value is always positive. It does not reflect which party benefits from the asymmetry; it captures only the degree of asymmetry.) We repeat this process using several sets of vote fractions which are equidistant from the majority line of 50%. Namely, we consider 45% and 55%, 46% and 54%, 47% and 53%, and 49% and 51%.

Reciprocity in a single election does not speak to possible variations in the spatial voting patterns seen across the state in different elections. Therefore, we repeat this procedure across the 16 historic statewide elections listed above, and then calculate an average of the absolute difference between the number of Republican seats elected (under the lower Democratic vote share) and the number of Democratic seats elected (under the higher Democratic vote share). The metric thus captures the average, absolute deviation, across elections and across vote shares, between the number of seats that the two parties are expected to elect at the same given vote share. Lower numbers reflect greater partisan symmetry, and in particular, reflect a more "equal opportunity to electing a supermajority or majority of representatives as the voters of the opposing party would be afforded if they comprised" a given percentage "of the statewide vote share in that same election." Harper slip op. ¶169.

We emphasize that we consider the average deviation across 16 different elections, thereby capturing the degree of partisan symmetry exhibited by the map across a variety of different election climates. This is very different from considering a single electoral vote pattern constructed by averaging elections to create a different, possibly unobserved, vote pattern, and only then assessing the deviation.

In addition to examining the averaged deviation from partisan symmetry, we also examine the mean-median difference and the efficiency gap. The mean-median is defined to be the difference between the average Democratic vote share and the median Democratic vote share.[1] The efficiency gap is defined to be the difference in wasted votes across the two parties

[1] Here we define Democratic/Republican vote share to be the fraction of the vote that went to one party compared with the vote going to both parties, i.e. $D/(R+D)$ where D and R are the Democratic and Republican votes in a district.

divided by the total vote for the two parties. Wasted votes are found by summing overall votes in losing districts and all votes in winning districts that are more than half the total votes; for example, if D and R are the Democratic and Republican votes in a district, and $D < R$ then the Democrats would have wasted D votes and the Republicans would have wasted $R - (D + R)/2$ votes. When computing the efficiency gap we uniformly swing each election to range from 45% to 55% of the vote in increments of 1%, which provides greater diversity to the elections considered. [2]

4 Congressional Districts

Using the set of statewide elections listed in Section 3, the partisan symmetry of the Harper Plaintiffs' proposed congressional map – as measured using the metric described below, which reflects the average deviation in seats won between the parties given a particular vote share – is 0.36875 seats. In practical terms, this means that for any given statewide election, the number of Democratic and Republican seats elected at a given party vote fraction will more often than not be the same number; and the expected difference averaged across a range of sixteen statewide elections is only 0.36875 seats. Only 96 of the 80,000 sampled congressional plans both accounted for incumbency and had a partisan symmetry score of less than 0.40 seats.

The legislature's 2022 remedial congressional plan has an average partisan symmetry deviation of 1.575 seats – meaning the average seat deviation between the parties given the same vote share is 4 times as high as it is in Harper plaintiffs proposed plan. This reflects that, under the enacted plan, Republicans win 8 or 9 seats when they get 51% of the vote, while Democrats win 7 or 8 seats when they get 51% of the vote. If the map makers would have examined just 20 random plans from our ensemble, they would have found a plan with higher partisan symmetry than the S745 plan with a 99.998% chance. Furthermore, there would be a 98.56% chance that at least one of those plans would have a seat deviation of less than 1. The 2022 enacted remedial Congressional plan has a mean-median gap of 1.01%. The average efficiency gap calculated by conducting uniform swings on these election results, ranging from 45% to 55% Democratic vote share, is 7.312%.

As to other partisan fairness metrics identified in the Supreme Courts order and opinion: The average mean-median difference for the Harper Plaintiffs' proposed map is 0.4504%. The average efficiency gap calculated by conducting uniform swings on these election results, ranging from 45% to 55% Democratic vote share, is 2.7180%.

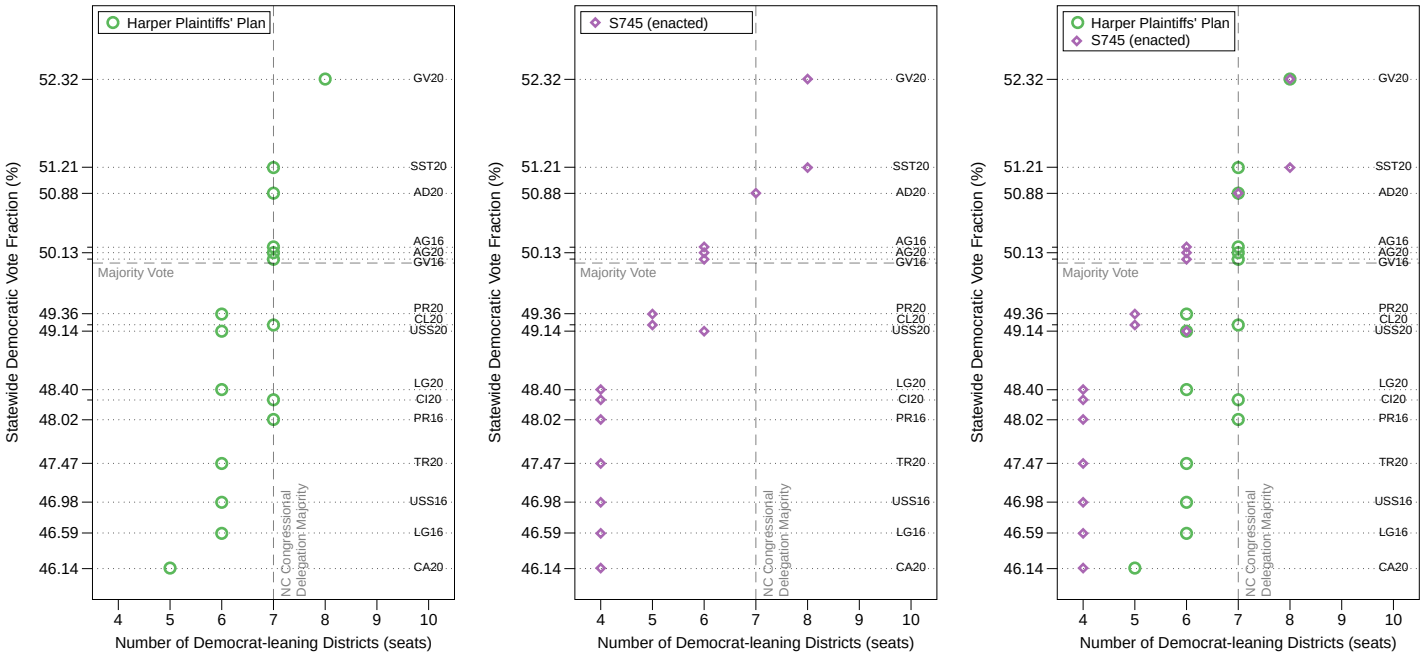


Figure 1: We show the number of seats (horizontal axis) compared with the statewide vote (vertical axis) in our 16 historic elections under the Harper Plaintiffs' map (left), and the enacted map (S745; middle). We also directly compare the two maps (right)

[2]When performing a uniform swing analysis, it is more efficient to estimate the efficiency gap using the Democratic/Republican vote fractions as opposed to the vote. Under equal votes in each district, the use of the fractions gives the exact same result, however, it will provide a slight difference if this is not true. When employing uniform swings, we use the vote fractions. In our experience, this sightly different formulation creates little difference in the values because the populations are balanced across districts.

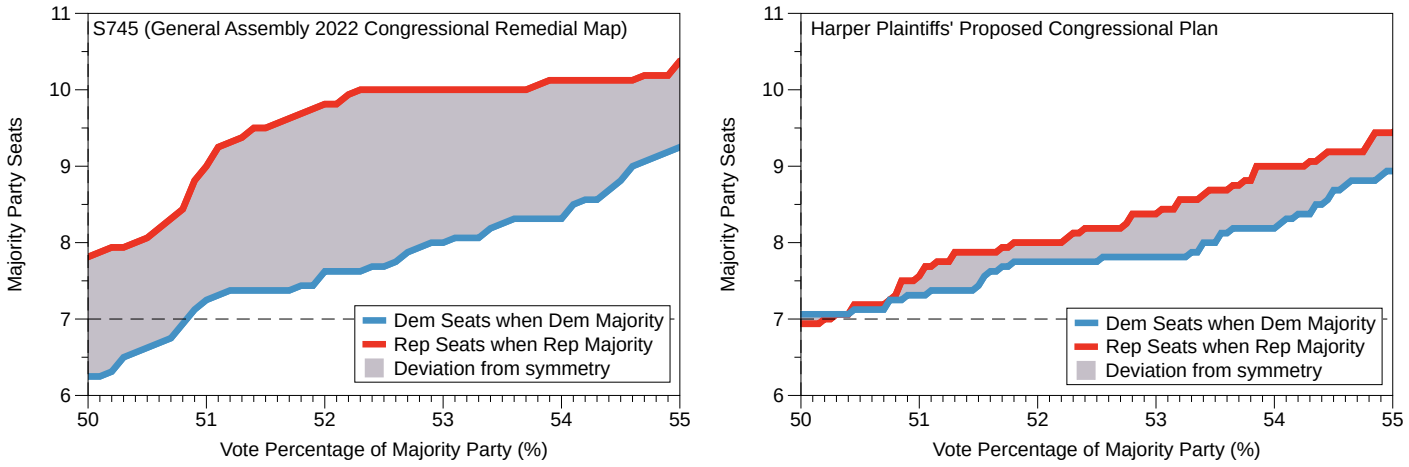


Figure 2: We show the statewide vote percentage won by the party in the majority of the vote (horizontal axis) compared with the statewide seats won by the majority party (vertical axis) in our 16 historic elections under the enacted map (S745; left), and the Harper Plaintiffs' plan (right). In a perfectly symmetric map, the blue line would always coincide with the red line.

To better illuminate the extent to which the two maps treat the parties symmetrically, we plot in Figure 1 what would be results of congressional elections run with historical elections mentioned in Section 3. We begin by noticing that the Harper Plaintiffs' proposed map always gives at at least half of the seats to the party which wins the majority of the votes. In contrast, the Legislature's S745 map only gives the Democrats at least half the seat in three of the six elections where they win the majority while always giving the Republicans at least half the seats in the elections where they win the majority of the votes. One can also understand the degree to which the maps produce seat counts which are symmetric. In a symmetric map, the behavior in the bottom half of these plots should "mirror" the behavior in the top half.

To better examine this, we calculate the seats won by the party with the majority of the vote under the sixteen specified elections when they are shifted, using the uniform swing hypothesis, to have a statewide Democratic share ranging from 45% to 55%. We then average these 16 seat counts over each of the statewide vote fractions. We plot this average in Figure 2 as a function of the statewide majority vote fraction. When the Democrats are in the Majority (Democratic vote shares of 50%-55%) we use a blue curve and plot the Democratic seat share. When the Republicans are in the Majority (Democratic vote shares of 45%-50%), we use a red curve and plot the Republican seat share. If the map is symmetric, the seats elected in response to Democratic majority votes will be the same as the seats elected in response to Republican majority votes, and the two curves will lie on top of each other. The gray shaded region emphasizes the deviation from ideal partisan symmetry.

Looking at Figure 2, we see that there is a significant deviation from symmetry in the legislature's proposed 2022 remedial Congressional plan while the Harper Plaintiffs' proposed plan shows a high degree of symmetry, particularly between 49% and 51%. Both maps favor the Republicans with respect to their deviation from partisan symmetry, as shown by the fact that the red curve is above the blue curve.

Democratic Elections						Republican Elections					
		S745 (Cong.)		Plaintiffs' Cong.				S745 (Cong.)		Plaintiffs' Cong.	
Election	Democratic Vote (%)	Dem. Seats	Dem. Split or Won Majority	Dem. Seats	Dem. Split or Won Majority	Election	Republican Vote (%)	Rep. Seats	Rep. Split or Won Majority	Rep. Seats	Rep. Split or Won Majority
GV16	50.05	6	**No**	7	Yes	PR20	50.64	9	Yes	8	Yes
AG20	50.13	6	**No**	7	Yes	CL20	50.78	9	Yes	7	Yes
AG16	50.20	6	**No**	7	Yes	USS 20	50.86	8	Yes	8	Yes
AD20	50.88	7	Yes	7	Yes	LG20	51.60	10	Yes	8	Yes
SST20	51.21	8	Yes	7	Yes	CI20	51.73	10	Yes	7	Yes
GV20	52.32	8	Yes	8	Yes	PR16	51.98	10	Yes	7	Yes
						TR20	52.53	10	Yes	8	Yes
						USS 16	53.02	10	Yes	8	Yes
						LG16	53.41	10	Yes	8	Yes
						CA20	53.85	10	Yes	9	Yes

Table 1: We summarize Figure 2 on the congressional two maps with the above table. Pay particular attention to the number of times which map fails to give a party the majority of seats when they win the majority of the votes. Notice that this only occurs for the Democrats.

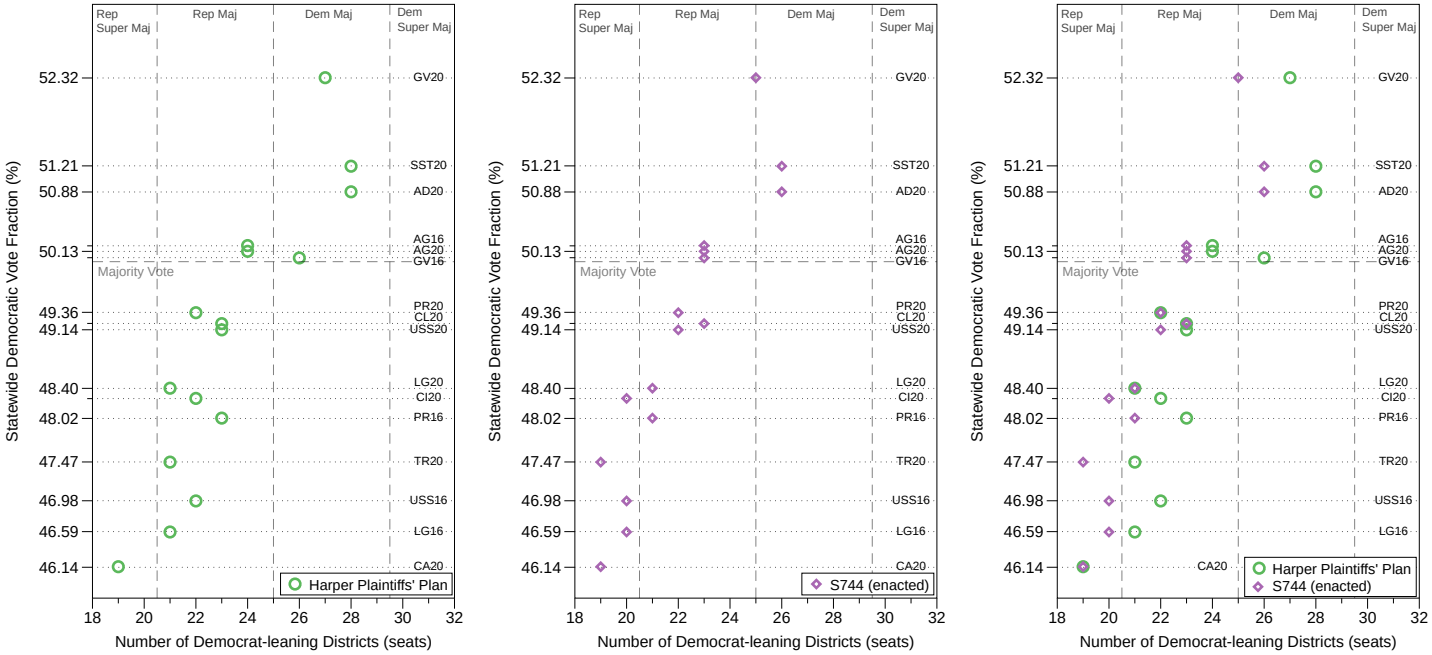


Figure 3: We show the number of seats (horizontal axis) compared with the statewide vote (vertical axis) in our 16 historic elections under the Harper Plaintiffs' map (left), and the NC Legislature's enacted map (S744; middle). We also directly compare the two maps (right).

5 Senate Districts

Using the set of statewide elections listed in Section 3, the partisan symmetry of the Harper Plaintiffs' proposed senate map – as measured using the metric described above for the congressional plans, which reflects the average deviation in seats won between the parties given a particular vote share – is 1.04375 seats.[3]

The legislature's 2022 enacted remedial senate plan has an average partisan symmetry deviation of 4.0125 seats – meaning the average seat deviation between the parties given the same vote share is again 4 times as high as it is in Harper plaintiffs proposed plan. This reflects that, under the enacted plan, Republicans win 29 or 30 seats when they get 52% of the vote, while Democrats win 25 or 26 seats when they get 52% of the vote. This is enough to potentially grant the Republicans a supermajority, whereas the Democrats either split the chamber or gain the smallest possible majority. If the map makers would have examined just 1 random plan from our ensemble, they would have found a plan with higher partisan symmetry than the S744 plan with a 99.6% chance. Furthermore, there would be a 92.5% chance that at least one of those plans would have a symmetry deviation of less than 3 seats. If they had considered 20 plans, they would have been essentially guaranteed to find one with a symmetry deviation of less than 3 seats. The 2022 enacted remedial Senate plan has a mean-median gap of 1.304%. The average efficiency gap calculated by conducting uniform swings on these election results, ranging from 45% to 55% Democratic vote share, is 4.072%.

As to other partisan fairness metrics identified in the Supreme Courts order and opinion: The average mean-median difference for the Harper Plaintiffs' proposed senate map is 0.228%. The average efficiency gap calculated by conducting uniform swings on these election results, ranging from 45% to 55% Democratic vote share, is 1.955%.

In Figure 3, we plot what would be results of North Carolina Senate elections run with historical elections mentioned in Section 3. We begin by noticing that both the Harper Plaintiffs' proposed NC Senate map and the Legislature's S744 map always give at least half of the seats to the Republican Party when they win the majority. The Harper Plaintiffs' proposed NC Senate map gives the majority of the seats to the Democrats in four out of six elections where they win the majority of the votes while the Legislature's S744 map does so in three out of six elections. More telling, the Legislature's S744 map gives the Republicans the supermajority of seats or close to it, when they receive between 51% and 52% of the votes while the Democrats barely get or share the majority when they receive between 51% and 52% of the votes.

To better understand the extent to which the two plans respond symmetrically to swings in the Democratic or Republican

[3]We remark that the coarse averaging of the measure we use is a rough approximation for the area of the gray regions shown in Figure 4 In this case, the 45%,55% vote pairing is over-weighted and drives the average up (there are only 4 other number we are averaging with). If we would have instead averaged the seat deviation across all vote fractions between 50%-55%, the deviation would have been closer to 0.5.

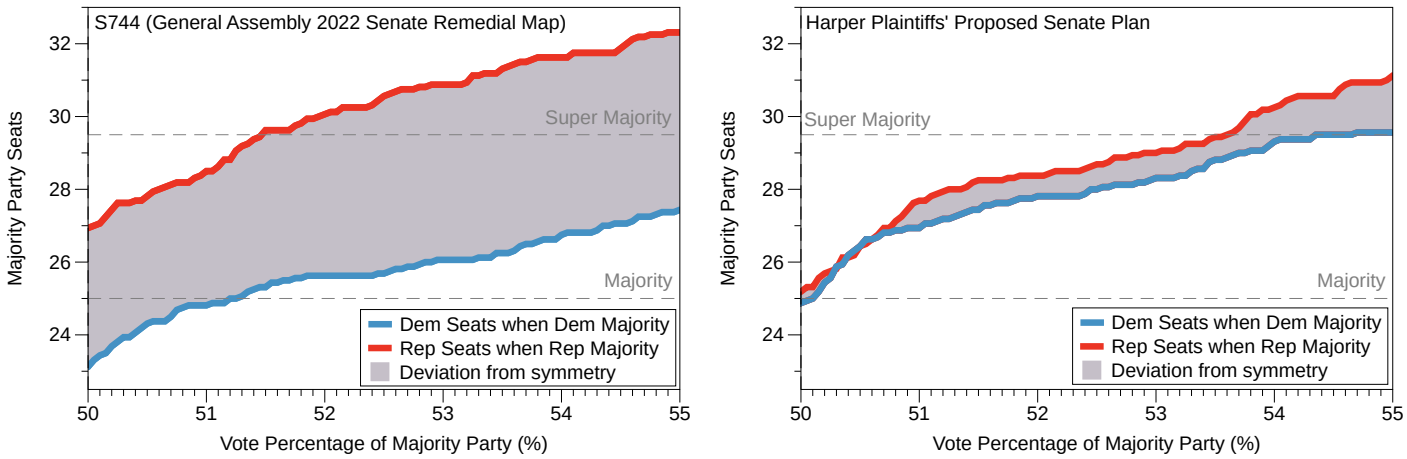


Figure 4: We show the statewide vote percentage won by the party with the majority of the vote (horizontal axis) compared with the statewide won seats by the majority party (vertical axis) in our 16 historic elections under the enacted map (S744; left), and the Harper Plaintiffs' plan (right). In a perfectly symmetric map, the blue line would always coincide with the red line

direction, we calculate the seats won by the party with the majority of the vote under the sixteen specified elections when they are shifted, using the uniform swing hypothesis, to have statewide Democratic share ranging from 45% to 55%. We then average these 16 seat counts over each of the statewide vote fractions. We plot this average in Figure 4 as a function of the statewide majority vote fraction. When the Democrats are in the Majority (Democratic vote shares of 50%-55%) we use a blue curve. When the Republicans are in the Majority (Democratic vote shares of 45%-50%), we use a red curve and plot the Republican seat share. If the response to Democratic majority votes is the same as Republican majority votes the two curves will be on top of each other. The gray shaded region emphasizes the deviation from ideal partisan symmetry.

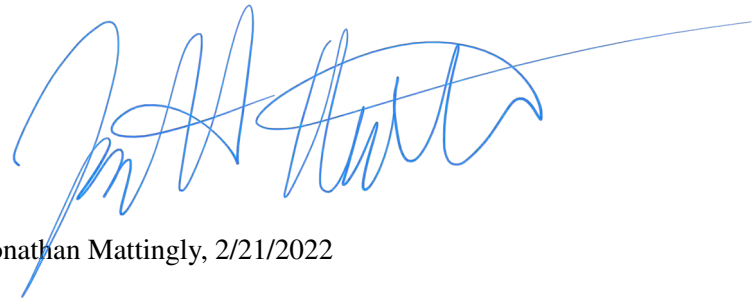
It is clear from Figure 4 that the Legislature's S744 map is significantly less symmetric than the Harper Plaintiffs' plan. It is particularly striking that Harper Plaintiffs' plan shows almost perfect symmetry for deviations immediately around 50%. Beyond that range the Harper Plaintiffs' plan actually treats Republicans more favorably than Democrats.

References

[1] Bernard Grofman and Gary King. The future of partisan symmetry as a judicial test for partisan gerrymandering after *LULAC v. Perry*. *Election Law Journal*, 6(1):457–472, 2007.

We declare under penalty of perjury under the laws of the state of North Carolina that the foregoing is true and correct to the best of our knowledge.

Greg Herschlag 2/21/2022



Jonathan Mattingly, 2/21/2022

CURRICULUM VITAE

Jonathan Christopher Mattingly

December 2021

120 Science Drive, I, Durham, NC 27708
297 Physics Building, Box 90320, Durham, NC 27708
jonathan.mattingly@duke.edu

CURRENT APPOINTMENTS AND AFFILIATIONS

Professor of Mathematics
James B. Duke Distinguished Professor
Professor of Statistical Science

EDUCATION, TRAINING AND CERTIFICATIONS

Ph.D., Princeton University 1998
B.S., Yale University 1992
High School, NC School of Science and Math, Durham NC 1988

APPOINTMENT HISTORY

Chair of the Department of Mathematics, Mathematics 2016 - 2020
Professor in the Department of Statistical Science, Statistical Science 2012 - 2015
Associate Professor, Statistical Science 2008 - 2011
Associate Professor of Mathematics, Mathematics 2006 - 2012
Assistant Professor of Mathematics, Mathematics 2002 – 2005
Member special year in SPDE/Tubulence, Institute for Advance Study, Princeton. 2002 - 2003
NSF Post-Doctoral Fellow, Stanford University. 1999 - 2002
Szego Assistant Professor of Mathematics, Stanford University. 1998 – 2002
Post-Doctoral Member, MSRI, UC Berkeley. 1998 - 1998
Contractor, AT&T Shannon Labs. 1999 – 1999 Summer Intern, Bell Labs, Lucent. 1996 - 1996

OTHER ACADEMIC POSITIONS

Member , Institute for Advance Study, Princeton, 2021
Simons Professor , MSRI, UC Berkeley. 2015 – 2015
Visiting Professor, Berlin Summer School, TU Berlin. 2009 - 2009
Visiting Member, Centro De Giorgi, SNS Pisa, Italy. 2006 - 2006
Visiting Professor, University de Marseilles. 2002 - 2002
Visiting Professor, MSRI, UC Berkeley. 2007 - 2007
Visiting Professor, University de Marseilles. 2010
Visiting Professor, University de Nice. 2012
Principle Lecturer, Saint Flour Summer school in Probability. 2007
Visiting Professor, University de Paris VI. 2008
Visiting Member, Institut Universitaire de France. 2003
Visiting Scholar, Mathematics Institute, Warwick University. 2000

PUBLICATIONS

Gao, Y., et al. “LIMITING BEHAVIORS OF HIGH DIMENSIONAL STOCHASTIC SPIN ENSEMBLES*.” Communications in Mathematical Sciences, vol. 19, no. 2, Jan. 2021, pp. 453–94. Scopus, doi:10.4310/CMS.2021.v19.n2.a7.

Li, L., et al. “Numerical Methods For Stochastic Differential Equations Based On Gaussian Mixture.” Communications in Mathematical Sciences, vol. 19, no. 6, Jan. 2021, pp. 1549–77. Scopus, doi:10.4310/CMS.2021.v19.n6.a5.

Bakhtin, Y., et al. “Singularities of invariant densities for random switching between two linear ODEs in 2D.” Siam Journal on Applied Dynamical Systems, vol. 20, no. 4, Jan. 2021, pp. 1917–58. Scopus, doi:10.1137/20M1364345.

Autry, Eric A., et al. “Metropolized Multiscale Forest Recombination for Redistricting.” Multiscale Modeling & Simulation, vol. 19, no. 4, Society for Industrial & Applied Mathematics (SIAM), Jan. 2021, pp. 1885–914. Crossref, doi:10.1137/21m1406854.

Gao, Y., et al. “Nonlocal stochastic-partial-differential-equation limits of spatially correlated noise-driven spin systems derived to sample a canonical distribution.” Physical Review E, vol. 102, no. 5, Nov. 2020. Scopus, doi:10.1103/PhysRevE.102.052112.

Gao, Yuan, et al. “Nonlocal stochastic-partial-differential-equation limits of spatially correlated noise-driven spin systems derived to sample a canonical distribution.” Physical Review. E, vol. 102, no. 5–1, Nov. 2020, p. 052112. Epmc, doi:10.1103/physreve.102.052112. PMID: 33327182.

Herschlag, G., et al. “Quantifying Gerrymandering in North Carolina.” Statistics and Public Policy, vol. 7, no. 1, Jan. 2020, pp. 30–38. Scopus, doi:10.1080/2330443X.2020.1796400.

AGAZZI, A., and J. C. MATTINGLY. “SEEMINGLY STABLE CHEMICAL KINETICS CAN BE STABLE, MARGINALLY STABLE, OR UNSTABLE.” Communications in Mathematical Sciences, vol. 18, no. 6, Jan. 2020, pp. 1605–42. Scopus, doi:10.4310/CMS.2020.v18.n6.a5.

Lu, Y., and J. C. Mattingly. “Geometric ergodicity of Langevin dynamics with Coulomb interactions.” Nonlinearity, vol. 33, no. 2, Jan. 2020, pp. 675–99. Scopus, doi:10.1088/1361-6544/ab514a.

Chikina, M., et al. “Separating Effect From Significance in Markov Chain Tests.” Statistics and Public Policy, vol. 7, no. 1, Jan. 2020, pp. 101–14. Scopus, doi:10.1080/2330443X.2020.1806763.

Carter, D., et al. “Optimal Legislative County Clustering in North Carolina.” Statistics and Public Policy, vol. 7, no. 1, Jan. 2020, pp. 19–29. Scopus, doi:10.1080/2330443X.2020.1748552.

Herzog, David P., and Jonathan C. Mattingly. “Ergodicity and Lyapunov Functions for Langevin Dynamics with Singular Potentials.” Communications on Pure and Applied Mathematics, vol. 72, no. 10, WILEY, Oct. 2019, pp. 2231–55. Wos, doi:10.1002/cpa.21862.

Chin, Andrew, et al. “The Signature of Gerrymandering in Rucho v. Common Cause.” South Carolina Law Review, vol. 70, 2019.

Herschlag, G., et al. Evaluating Partisan Gerrymandering in Wisconsin. Sept. 2017.

Bakhtin, Y., et al. Smooth invariant densities for random switching on the torus (Submitted). Aug. 2017.

Johndrow, J. E., and J. C. Mattingly. Coupling and Decoupling to bound an approximating Markov Chain (Submitted). July 2017.

Glatt-Holtz, N. E., et al. “Scaling and Saturation in Infinite-Dimensional Control Problems with Applications to Stochastic Partial Differential Equations (Accepted).” Annals of Pde, June 2017.

Hairer, M., and J. Mattingly. The strong Feller property for singular stochastic PDEs (Submitted). 2016.

Tempkin, J. O. B., et al. “Trajectory stratification of stochastic dynamics (Accepted).” Siam Review, Society for Industrial and Applied Mathematics, 2016. PMID: 34650314. PMCID: PMC8514164.

Munch, E., et al. “Probabilistic Fréchet means for time varying persistence diagrams.” Electronic Journal of Statistics, vol. 9, Jan. 2015, pp. 1173–204. Scopus, doi:10.1214/15-EJS1030.

Luo, S., and J. C. Mattingly. Scaling limits of a model for selection at two scales. 2015. PMID: 28867875. PMCID: PMC5580332.

Glatt-Holtz, N., et al. On Unique Ergodicity in Nonlinear Stochastic Partial Differential Equations (Submitted). 2015.

Herzog, David P., and Jonathan Christopher Mattingly. Noise-Induced Stabilization of Planar Flows II. Apr. 2014.

Mattingly, Jonathan C., and Etienne Pardoux. “Invariant measure selection by noise. An example.” Discrete and Continuous Dynamical Systems. Series A, vol. 34, 2014, pp. 4223–57. Manual, doi:10.3934/dcds.2014.34.4223.

Lawley, Sean D., et al. “Sensitivity to switching rates in stochastically switched ODEs.” Communications in Mathematical Sciences, vol. 12, 2014, pp. 1343–52. Manual, doi:10.4310/CMS.2014.v12.n7.a9.

Herzog, David P., and Jonathan C. Mattingly. “Noise-Induced Stabilization of Planar Flows I.” Arxiv Preprint Arxiv:1404.0957, 2014.

Bakhtin, Yuri, et al. “Regularity of invariant densities for 1D-systems with random switching.” Arxiv Preprint Arxiv:1406.5425, 2014.

Lawley, Sean D., et al. “Stochastic switching in infinite dimensions with applications to random parabolic PDEs.” Arxiv Preprint Arxiv:1407.2264, 2014.

Herzog, David P., and Jonathan C. Mattingly. “A practical criterion for positivity of transition densities.” Arxiv Preprint Arxiv:1407.3858, 2014.

Huckemann, Stephan, et al. “Sticky central limit theorems at isolated hyperbolic planar singularities.” Arxiv Preprint Arxiv:1410.6879, 2014.

Mattingly, Jonathan C., and Christy Vaughn. “Redistricting and the Will of the People.” Arxiv Preprint Arxiv:1410.8796, 2014.

Hotz, Thomas, et al. “Sticky central limit theorems on open books.” The Annals of Applied Probability, vol. 23, 2013, pp. 2238–58. Manual, doi:10.1214/12-AAP899.

Mattingly, J. C., et al. “Geometric ergodicity of a bead-spring pair with stochastic Stokes forcing.” Stochastic Processes and Their Applications, vol. 122, no. 12, Dec. 2012, pp. 3953–79. Scopus, doi:10.1016/j.spa.2012.07.003.

Luo, Shishi, et al. “The impact of host immune status on the within-host and population dynamics of antigenic immune escape.” J R Soc Interface, vol. 9, no. 75, Oct. 2012, pp. 2603–13. Pubmed, doi:10.1098/rsif.2012.0180. PMID: 22572027. PMCID: PMC3427510.

Athreyaz, A., et al. “Propagating lyapunov functions to prove noise-induced stabilization.” Electronic Journal of Probability, vol. 17, 2012. Scival, doi:10.1214/EJP.v17-2410.

Porporato, A., et al. “Local kinetic interpretation of entropy production through reversed diffusion.” Phys Rev E Stat Nonlin Soft Matter Phys, vol. 84, no. 4 Pt 1, Oct. 2011, p. 041142. Pubmed, doi:10.1103/PhysRevE.84.041142. PMID: 22181122.

Hairer, Martin, and Jonathan C. Mattingly. Yet another look at Harris’ ergodic theorem for Markov chains. Vol. 63, Birkhäuser/Springer Basel AG, Basel, 2011, pp. 109–17. Manual, doi:10.1007/978-3-0348-0021-1_7.

Hairer, M., et al. “Asymptotic coupling and a general form of Harris' theorem with applications to stochastic delay equations.” Probability Theory and Related Fields, vol. 149, no. 1, 2011, pp. 223–59. Scival, doi:10.1007/s00440-009-0250-6.

Anderson, D. F., and J. C. Mattingly. “A weak trapezoidal method for a class of stochastic differential equations.” Communications in Mathematical Sciences, vol. 9, no. 1, 2011, pp. 301–18.

Hairer, M., and J. C. Mattingly. “A theory of hypoellipticity and unique ergodicity for semilinear stochastic PDEs.” Electronic Journal of Probability, vol. 16, 2011, pp. 658–738.

Koelle, K., et al. “A dimensionless number for understanding the evolutionary dynamics of antigenically variable RNA viruses.” Proceedings of the Royal Society B: Biological Sciences, vol. 278, no. 1725, 2011, pp. 3723–30. Scival, doi:10.1098/rspb.2011.0435. PMID: 21543353. PMCID: PMC3203497.

Cooke, Ben, et al. “Geometric Ergodicity of Two–dimensional Hamiltonian systems with a Lennard–Jones–like Repulsive Potential.” Arxiv Preprint Arxiv:1104.3842, 2011.

Mattingly, J. C., et al. “Convergence of numerical time-averaging and stationary measures via Poisson equations.” Siam Journal on Numerical Analysis, vol. 48, no. 2, 2010, pp. 552–77. Scival, doi:10.1137/090770527.

Hairer, M., and J. C. Mattingly. “Slow energy dissipation in anharmonic oscillator chains.” Communications on Pure and Applied Mathematics, vol. 62, no. 8, 2009, pp. 999–1032. Scival, doi:10.1002/cpa.20280.

Martin Hairer, Jonathan C. “Spectral gaps in Wasserstein distances and the 2D stochastic Navier-Stokes equations.” Annals of Probability, no. 6, 2008, pp. 993–1032.

Iyer, Gautam, and Jonathan Mattingly. “A stochastic-Lagrangian particle system for the Navier-Stokes equations.” Nonlinearity, vol. 21, 2008, pp. 2537–53. Manual, doi:10.1088/0951-7715/21/11/004.

Mattingly, J. C., et al. “Simple systems with anomalous dissipation and energy cascade.” Communications in Mathematical Physics, vol. 276, no. 1, Nov. 2007, pp. 189–220. Scopus, doi:10.1007/s00220-007-0333-0.

Anderson, D. F., and J. C. Mattingly. “Propagation of fluctuations in biochemical systems, II: Nonlinear chains.” Iet Systems Biology, vol. 1, no. 6, Nov. 2007, pp. 313–25. Epmc, doi:10.1049/iet-syb:20060063. PMID: 18203578.

Bakhtin, Y., and J. C. Mattingly. “Malliavin calculus for infinite-dimensional systems with additive noise.” Journal of Functional Analysis, vol. 249, no. 2, Aug. 2007, pp. 307–53. Scopus, doi:10.1016/j.jfa.2007.02.011.

Anderson, David F., et al. “Propagation of fluctuations in biochemical systems, I: linear SSC networks.” Bulletin of Mathematical Biology, vol. 69, no. 6, Aug. 2007, pp. 1791–813. Epmc, doi:10.1007/s11538-007-9192-2. PMID: 17457656.

Lamba, H., et al. “An adaptive Euler-Maruyama scheme for SDEs: Convergence and stability.” Ima Journal of Numerical Analysis, vol. 27, no. 3, Jan. 2007, pp. 479–506. Scopus, doi:10.1093/imanum/drl032.

Mattingly, J. C., et al. “Anomalous dissipation in a stochastically forced infinite-dimensional system of coupled oscillators.” Journal of Statistical Physics, vol. 128, no. 5, 2007, pp. 1145–52. Scival, doi:10.1007/s10955-007-9351-8.

Nijhout, H. Frederik, et al. “Erratum to H. Frederik Nijhout, et al. Epigenetics Volume 1, Issue 2; pp. 81-87.” Epigenetics, vol. 1, no. 3, Informa UK Limited, July 2006, pp. 115–115. Crossref, doi:10.4161/epi.1.3.3281.

Hairer, M., and J. C. Mattingly. “Ergodicity of the 2D Navier-Stokes equations with degenerate stochastic forcing.” Annals of Mathematics, vol. 164, no. 3, 2006, pp. 993–1032.

Mattingly, J. C., and É. Pardoux. “Malliavin calculus for the stochastic 2D Navier-Stokes equation.” Communications on Pure and Applied Mathematics, vol. 59, no. 12, 2006, pp. 1742–90. Scival, doi:10.1002/cpa.20136.

Bakhtin, Y., and J. C. Mattingly. “Stationary solutions of stochastic differential equations with memory and stochastic partial differential equations.” Communications in Contemporary Mathematics, vol. 7, no. 5, Oct. 2005, pp. 553–82. Scopus, doi:10.1142/S0219199705001878.

Mattingly, J. C., and T. M. Suidan. “The small scales of the stochastic Navier-Stokes equations under rough forcing.” Journal of Statistical Physics, vol. 118, no. 1–2, Jan. 2005, pp. 343–64. Scopus, doi:10.1007/s10955-004-8787-3.

Hairer, Martin, et al. “Malliavin calculus and ergodic properties of highly degenerate 2D stochastic Navier–Stokes equation.” Arxiv Preprint Math/0409057, 2004.

Hairer, Martin, et al. “Malliavin calculus for highly degenerate 2D stochastic Navier-Stokes equations.” Comptes Rendus Mathématique. Académie Des Sciences. Paris, vol. 339, 2004, pp. 793–96. Manual, doi:10.1016/j.crma.2004.09.002.

Hairer, Martin, and Jonathan C. Mattingly. “Ergodic properties of highly degenerate 2D stochastic Navier-Stokes equations.” Comptes Rendus Mathématique. Académie Des Sciences. Paris, vol. 339, 2004, pp. 879–82. Manual, doi:10.1016/j.crma.2004.09.035.

Mattingly, Jonathan C. On recent progress for the stochastic Navier Stokes equations. Univ. Nantes, Nantes, 2003, p. Exp.No.XI-52.

Mattingly, Jonathan C. “The dissipative scale of the stochastics Navier-Stokes equation: regularization and analyticity.” Journal of Statistical Physics, vol. 108, 2002, pp. 1157–79. Manual, doi:10.1023/A:1019799700126.

Mattingly, J. C., et al. “Ergodicity for SDEs and approximations: locally Lipschitz vector fields and degenerate noise.” Stochastic Processes and Their Applications, vol. 101, 2002, pp. 185–232. Manual, doi:10.1016/S0304-4149(02)00150-3.

Mattingly, J. C. “Contractivity and ergodicity of the random map $x\mapsto\vert x-θ\vert $.” Rossi\U\I Skaya Akademiya Nauk. Teoriya Veroyatnoste\U\I I Ee Primeneniya, vol. 47, 2002, pp. 388–97. Manual, doi:10.1137/S0040585X97979767.

Mattingly, Jonathan C. “Exponential convergence for the stochastically forced Navier-Stokes equations and other partially dissipative dynamics.” Communications in Mathematical Physics, vol. 230, 2002, pp. 421–62. Manual, doi:10.1007/s00220-002-0688-1.

Mattingly, J. C., and A. M. Stuart. “Geometric ergodicity of some hypo-elliptic diffusions for particle motions.” Markov Processes and Related Fields, vol. 8, 2002, pp. 199–214.

Mattingly, Jonathan Christopher. “Contractivity and ergodicity of the random map $x\mapsto|x-\theta|$.” Teoriya Veroyatnostei I Ee Primeneniya, vol. 47, no. 2, Steklov Mathematical Institute, 2002, pp. 388–97. Crossref, doi:10.4213/tvp3671.

E, Weinan, et al. “Gibbsian dynamics and ergodicity for the stochastically forced Navier-Stokes equation.” Communications in Mathematical Physics, vol. 224, 2001, pp. 83–106. Manual, doi:10.1007/s002201224083.

E, Weinan, and Jonathan C. Mattingly. “Ergodicity for the Navier-Stokes equation with degenerate random forcing: finite-dimensional approximation.” Communications on Pure and Applied Mathematics, vol. 54, 2001, pp. 1386–402. Manual, doi:10.1002/cpa.10007.

Mattingly, Jonathan C. “Ergodicity of 2D Navier-Stokes equations with random forcing and large viscosity.” Communications in Mathematical Physics, vol. 206, 1999, pp. 273–88. Manual, doi:10.1007/s002200050706.

Mattingly, J. C., and Ya G. Sinai. “An elementary proof of the existence and uniqueness theorem for the Navier-Stokes equations.” Communications in Contemporary Mathematics, vol. 1, 1999, pp. 497–516. Manual, doi:10.1142/S0219199799000183.

Holmes, Philip J., et al. “Low-dimensional models of coherent structures in turbulence.” Physics Reports. a Review Section of Physics Letters, vol. 287, 1997, pp. 337–84. Manual, doi:10.1016/S0370-1573(97)00017-3.

Johndrow, James E., et al. Optimal approximating Markov chains for Bayesian inference.

Bangia, Sachet, et al. Redistricting: Drawing the Line.

Johndrow, James E., and Jonathan C. Mattingly. Error bounds for Approximations of Markov chains used in Bayesian Sampling.

Wang, Chuang, et al. Scaling Limit: Exact and Tractable Analysis of Online Learning Algorithms with Applications to Regularized Regression and PCA.

Carter, Daniel, et al. A Merge-Split Proposal for Reversible Monte Carlo Markov Chain Sampling of Redistricting Plans.

Herschlag, Gregory, et al. Non-reversible Markov chain Monte Carlo for sampling of districting maps.

Autry, Eric A., et al. Multi-Scale Merge-Split Markov Chain Monte Carlo for Redistricting.

Leimbach, Matti, et al. Noise-induced strong stabilization.

Mattingly, Jonathan C., et al. The Gaussian Structure of the Singular Stochastic Burgers Equation.

Herzog, David P., et al. Gibbsian dynamics and the generalized Langevin equation.

Earle, Gabriel, and Jonathan Mattingly. Convergence of Stratified MCMC Sampling of Non-Reversible Dynamics.

Mattingly, Jonathan C., et al. “Diffusion limits of the random walk Metropolis algorithm in high dimensions.” Annals of Applied Probability, vol. 22, no. 3, pp. 881–930. Arxiv, doi:10.1214/10-AAP754.

Heymann, Matthias, et al. Rare Transition Events in Nonequilibrium Systems with State-Dependent Noise: Application to Stochastic Current Switching in Semiconductor Superlattices.

Theses and Dissertations

Mattingly, Jonathan. The Stochastic Navier-Stokes Equation: Energy Estimates and Phase Space Contraction, under Yakov Sinai.

PROFESSIONAL AWARDS AND SPECIAL RECOGNITION

IE Block Community Lecture. SIAM. 2021

Defenders of Democracy. National Common Cause. 2018

Fellow of the American Mathematical Society . American Mathematical Society. 2015

Simons Visiting Professor . MSRI. 2015

Institute of Mathematical Statistics Fellow. Institute of Mathematical Statistics. 2012

Faculty Early Career Development (CAREER) Program. National Science Foundation. 2005

Presidential Early Career Awards for Scientists and Engineers. National Science Foundation. 2005
Sloan Research Fellowship-Mathematics. Alfred P. Sloan Foundation. 2005
School of Mathematics/ Members. Institute for Advanced Study. 2002

PRESENTATIONS AND APPEARANCES

Sampling to Understand Gerrymandering and Influence Public Policy. MIT. January 1, 2021
Panel on Qunatifying Gerrymandering. Democracy in America. October 1, 2021
Hearing the Will of the People. ISM. August 1, 2021
Non-rversible samplers for Gerrymandering. Netherlands. August 1, 2021
The Gaussian Structure of the Stochastically Forced Burgers Equation. Berlin. May 1, 2021
The Mathematics and Policy of Gerrymandering. IAS. December 1, 2021
Gaussian Structure of Burgers Equation. India (online). January 1, 2021
A new model of randomly forced Fluid equations. Princeton Fluids Seminar. November 1, 2021
A new model of randomly forced Fluid equations. ICEM. October 1, 2021
A new model of randomly forced Fluid equations. IAS. December 1, 2021

Gaussian Structure of Stochastic Burgers. February 1, 2021
New Sampling Methods of Quantifying Gerrymandering . Brown Applied Math Colloquium . October 1, 2020
Interactions between noise and instabilities.. IHP, Paris. July 1, 2018
Quantifying Gerrymandering: A Mathematician Goes to Court. July 1, 2018
Ergodicity of Singular SPDEs. Columbia. May 1, 2018
Approximate/exact controllability and ergodicity for (additive noise) SPDEs/SODEs. CIRM, Marseilles 2018
Discovering the geopolitical structure of the United States through Markov Chain Monte Carlo sampling. The Alan Turing Institute, UK. May 1, 2018
Drawing the line in redistricting (A mathematician's take). Stanford University. March 1, 2018
Ergodic and global solutions for singular SPDEs. Corvallis, Oregon. March 1, 2018
A mathematician Goes to Court. October 1, 2017
Stabilization of Stochastic Dynamics . UCLA. IPAM. January 1, 2017
Stabilization and noise. Berekey Mathematics Department. November 12, 2015
Stochastic PDEs. October 1, 2015
Ergodicity Finite and Infinite dimentional Markov Chains. McGill University. July 1, 2015

Lectures

New Sampling Methods to Quantify Gerymandering. IID. Duke Law and TRIPODS. March 1, 2020
Anatomy of an ergodic theorem. Summer School. June 1, 2018
Dynamics Days 2014. Atlanta GA. January 4, 2014
Stabilization by Noise. November 19, 2013
Uniqueness of the inviscid limit in a simple model damped/driven system.. Probability and Mathematical Physics Seminar. November 5, 2013
Stochastic stabilization of OEDs.. Applied Math Seminar, NYU. September 6, 2013
Stochastic partial differential equations. SPA2013. August 1, 2013
Stabilization by noise. University of Maryland. May 1, 2013
Stablization by Noise. Conférence en l'honneur d'Etienne Pardoux, CIRM, Marseillais France.. February 14, 2013
Perspectives on Ergodicity. Conference on SPDEs, IMA, Minnesota. January 14, 2013

A Numerical Method for the SDEs from Chemical Equations. Probability and Biology section, 2012 Canadian Mathematical society (winter meeting). December 1, 2012

Minerva Lectures: Erodicity of Markov Processes: From Chains to SDEs to SPDEs. Mathematics Department, Columbia University. November 1, 2012

Stochastic Stabilization. Inria - Sophia Antipolis. July 1, 2012

A Menagerie of Stabilization. Joint Probability and Analysis Seminar, Nice, France. July 1, 2012

Building Lyapunov Functions (4 lectures). EPSRC Symposium Workshop – Easter Probability Meeting. March 1, 2012

Noise Induced Stability. MBI. February 1, 2012

A Menagerie of Stochastic Stabilization. CAMP/Probability Seminar, University of Chicago. October 18, 2011

A menagerie of stochastic stabilization. Equadiff 2011, Loughborough University. August 1, 2011

Coarse–graining of many–body systems: analysis, computations and applications. July 1, 2011

Ergodicity of systems with singular interaction terms. Stochastic Dynamics Transition Workshop, SAMSI. November 18, 2010

Oberwolfach Seminar: The Ergodic Theory of Markov Processes. Oberwolfach, Germany. October 1, 2010

Malliavin Calculus to prove ergodic theorems for SPDEs. ICM Satellite Conference on Probability and Stochastic Processes Indian Statistical Institute, Bangalore. August 13, 2010

SPDE scaling limits of an Markov chain Montecarlo algorithm. Stochastic Partial Differential Equations: Approximation, Asymptotics and Computation, Newton Institute. June 28, 2010

The spread of randomness. German-American Frontiers of Science, Potsdam Germany. June 1, 2010

How to prove an ergodic theorem. oberwolfach. May 1, 2010

Coupling at infinity. Seminar on Stochastic Processes. March 30, 2010

Long time stochastic simiulation. Imperial College. March 15, 2010

Spectral Gaps in Wasserstien Distance. Ergodic Theory Seminary, Princeton Mathematics. March 4, 2010

Trouble with a chain of stochastic oscillators. PACM, Princeton University. March 2, 2010

Hypo-ellipticity for SPDEs. SPDE program , Newton Institute. March 1, 2010

Numerics of SDEs. Warwick University, UK. February 24, 2010

Long Time Behavior of Stochastically Forced PDEs.. AMS Joint Meeting, San Francisco. January 14, 2010

Ellipticity and Hypo-ellipticity for SPDEs *or* What is ellipticity in infinite dimensions anyway?. Stochastic Partial Differential Equations, Newton Institute. January 8, 2010

SPDE Limits of the Random Walk Metropolis Algorithm in High Dimensions. SIAM PDE Meeting. December 7, 2009

Stochastic fluctuations in bio chemical networks. MBI: Mathematical Developments Arising from Biology. November 9, 2009

What makes infinite dimensional Markov processes different ?. Stochastic Process and Applications, Berlin. July 1, 2009

Introduction to Ergodicity in Infinite Dimentions. TU Berlin. July 1, 2009

Stochastically forced fluid equations: Transfer between scales and ergodicity.. AMS Sectional Meeting (invited talk). April 4, 2009

Trouble with a chain of stochastic oscillators. Princeton University. PACM. April 3, 2009

What makes the ergodic theory if Markov Chains in infinite dimensions different (and dificult) ?. Princeton Ergodic theory seminar. March 3, 2009

Ergodicity, Energy Transfer, and Stochastic Partial Differential Equations. Columbia University. Columbia University. December 15, 2008

The Spread of Randomness: Ergodicity in Infinite Dimensions. Mathematisches Forschungsinstitut Oberwolfach. December 15, 2008

The spread of randomness through dimensions. IPAM. November 1, 2008

The spread of randomness through dimensions. IPAM- Mathematical Frontiers in Network Multi-Resolution Analysis. November 1, 2008

Troubles with oscillators. Stanford: JBK85, Workshop on Applied Mathematics IN HONOR OF JOSEPH B. KELLER. October 1, 2008

What is different about the ergodic theory of stochastic PDEs (vs ODEs). UC Irvine, PDE and Probabilty Seminar. October 1, 2008

Trouble with a chain of stochastic oscillators. Stochastic Seminar, GaTech. September 1, 2008

Troubles with oscillators. East Midlands Stochastic Analysis Seminars. August 1, 2008

Troubles with chains of anharmonic oscillators. Statisical Mechaniques working group. June 1, 2008

The spread of randomness in infinite dimensions and ergodicity for SPDEs. Stochastic Analysis, Random Fields and Applications, Asscona IT. June 1, 2008

Ergodicity of Degenerately forced SPDEs. Séminaire de Probabilités, Laboratoire de Probabilités et Modèles Aléatoires des Universités Pierre et Marie Curie et Denis Diderot. May 27, 2008

Ergodicity of Degenerately forced SPDEs. ETH, Zurich. May 1, 2008

Named Lectures

Barton Lectures in Computational Mathematics. UNCG. November 1, 2021

IE Block Community Lecture . SIAM Annual Meeting. SIAM. July 1, 2021

Quantifying and Understanding Gerrymandering - How a quest to understand his state's political geography led a mathematician to court. ICERM . October 1, 2020

AMS Regional Meeting Plenary Speaker. Gainesville . AMS. January 1, 2019

Long Time Numerical Simulation of SDEs. Insbruk. SciCADE2019 . January 1, 2019

Quantifying Gerrymandering: A mathematician goes to court. UBC. May 1, 2018

Quantifying Gerrymandering: a mathematician goes to court. Stanford Mathematics Department. March 1, 2018

Stochastic PDEs. July 1, 2016

Event/Org Administration

Co-Organizer . Quantifying Gerrymandering. SAMSI. October 2018

Co-Organizer . Regional Gerrymandering Conference. November 2017

Co-Organizer . Interacting particle systems WITH APPLICATIONS IN BIOLOGY, ECOLOGY, AND STATISTICAL PHYSICS. SEPC 2017. May 2017

Organiser Special Term. MSRI, Berkeley CA. August 2015 - December 2015

Organized invited session at SPA2013. August 2013

Co Organizer (with Amarjit Budhiraja) : Seminar on Stochastic Processes 2013. March 2013

Local Orgnaizer (with Rick Durrett) : Woman in Probability III. October 2012

SAMSI Stochastic Dynamics tradition workshop. November 2010

MFO week long school on ergodic theory. October 2010

SAMSI Opening Workshop for Stochastic Dynamics. August 2009

local liaison/Organizer SAMSI year on stochastic dynamics. 2009 - 2010

Organiser Special Term. MSRI, Berkeley CA. August 2007 - December 2007

CURRICULUM VITAE

Gregory Joseph Herschlag, Ph.D.
Assistant Research Professor
gjh@math.duke.edu

CURRENT APPOINTMENTS AND AFFILIATIONS

Assistant Research Professor of Mathematics

EDUCATION, TRAINING AND CERTIFICATIONS

Ph.D., Department of Mathematics, University of North Carolina - Chapel Hill, 2013
- Thesis supervisor: Prof. Sorin Mitran.
- Thesis: Multiple Scale Algorithm Design for Advancing Fronts

BS with Honors, University of Chicago, 2007

DUKE APPOINTMENT HISTORY

Phillip Griffiths Assistant Research Professor 2018-2019

Visiting Assistant Professor of Mathematics, Mathematics 2013 - 2018

PUBLICATIONS

Academic Articles

Autry, Eric A., Daniel Carter, Gregory J. Herschlag, Zach Hunter, and Jonathan C. Mattingly. "Metropolized Multiscale Forest Recombination for Redistricting." Multiscale Modeling & Simulation 19, no. 4 (January 2021): 1885–1914. https://doi.org/10.1137/21m1406854.

G. Herschlag, S. Lee, J. Vetter and A. Randles, "Analysis of GPU Data Access Patterns on Complex Geometries for the D3Q19 Lattice Boltzmann Algorithm," in IEEE Transactions on Parallel and Distributed Systems, 2021, doi: 10.1109/TPDS.2021.3061895.

Herschlag, G., Kang, H. S., Luo, J., Graves, C. V., Bangia, S., Ravier, R., & Mattingly, J. C. (2020). Quantifying gerrymandering in north carolina. Statistics and Public Policy, 7(1), 30-38. doi:10.1080/2330443X.2020.1796400.

Carter, D., Hunter, Z., Teague, D., Herschlag, G., & Mattingly, J. (2020). Optimal Legislative County Clustering in North Carolina. Statistics and Public Policy, 7(1), 19-29. doi:10.1080/2330443X.2020.1748552.

Herschlag, G., J. Gounley, S. Roychowdhury, E. Draeger, and A. Randles. "Multi-physics simulations of particle tracking in arterial geometries with a scalable moving window algorithm." Proceedings Ieee International Conference on Cluster Computing, Iccc, vol. 2019-September, 2019. Scopus, doi:10.1109/CLUSTER.2019.8891041.

Chin, A., Herschlag, G., & Mattingly, J. (2018). The Signature of Gerrymandering in Rucho v. Common Cause. SCL Rev., 70, 1241.

Herschlag, G., Lee, S., Vetter, J. S., & Randles, A. (2018, May). GPU data access on complex geometries for D3Q19 lattice Boltzmann method. In 2018 IEEE International Parallel and Distributed Processing Symposium (IPDPS) (pp. 825-834). IEEE, doi:10.1109/IPDPS.2018.00092.

Cao, Y., Feng, Y., Ryser, M. D., Zhu, K., Herschlag, G., Cao, C., ... & You, L. (2017). Programmable assembly of pressure sensors using pattern-forming bacteria. Nature biotechnology, 35(11), 1087-1093. PMID: 28991268. PMCID: 28991268.

Herschlag, G., Liu, J. G., & Layton, A. T. (2016). Fluid extraction across pumping and permeable walls in the viscous limit. Physics of Fluids, 28(4), 041902, doi:10.1063/1.4946005.

Herschlag, G. J., Mitran, S., & Lin, G. (2015). A consistent hierarchy of generalized kinetic equation approximations to the master equation applied to surface catalysis. The Journal of chemical physics, 142(23), 234703. doi:10.1063/1.4922515. PMID: 26093569. PMCID: 26093569.

Herschlag, G., Liu, J. G., & Layton, A. T. (2015). An exact solution for stokes flow in a channel with arbitrarily large wall permeability. SIAM Journal on Applied Mathematics, 75(5), 2246-2267, doi:10.1137/140995854.

G. Herschlag, T. C. Elston, M. G. Forest, G. Garcia, B. Reinhardt, B. Button, R. Tarran and B. Lindley. A mechanochemical model for auto-regulation of lung airway surface layer volume. Journal of Theoretical Biology. 325 (2013) 4251

G. Herschlag and L. A. Miller. Reynolds number limits for jet propulsion: A numerical study of simplified jellyfish. Journal of Theoretical Biology 285 (2011) 84-95

Pre-prints

Herschlag, G., Mattingly, J. C., Sachs, M., & Wyse, E. (2020). Non-reversible Markov chain Monte Carlo for sampling of districting maps. arXiv preprint arXiv:2008.07843.

Carter, D., Herschlag, G., Hunter, Z., & Mattingly, J. (2019). A merge-split proposal for reversible monte carlo markov chain sampling of redistricting plans. arXiv preprint arXiv:1911.01503.

Herschlag, G., Ravier, R., & Mattingly, J. C. (2017). Evaluating partisan gerrymandering in Wisconsin. arXiv preprint arXiv:1709.01596.

Other work

Contributer and maintainer of the Duke Quantifying Gerrymandering Blog at https://sites.duke.edu/quantifyinggerrymandering/ (2018-present)

Aided in preparing the affidavit of Jonathan Mattingly in Harper v. Lewis https://sites.duke.edu/quantifyinggerrymandering/files/2019/12/Mattingly-Nov.-26-Declaration.pdf (2019)

Aided in preparing the expert report and rebuttal of Jonathan Mattingly in Common Cause v. Lewis. https://sites.duke.edu/quantifyinggerrymandering/files/2019/09/Report.pdf (2019)

Guy-Uriel Charles, Andrew Chin, Gregory Herschlag and Jonathan C. Mattingly. Op-Ed: "The fight against partisan gerrymandering continues." Harold Sun https://www.heraldsun.com/opinion/article217639645.html August 31, 2018 10:25 AM

Herschlag. Affidavit on Evidence of Racial Gerrymandering in Covington V. North Carolina (2017)

Aided in preparing the expert report of Jonathan Mattingly in Rucho v. Common Cause. https://s10294.pcdn.co/wp-content/uploads/2016/05/Expert-Report-of-Jonathan-Mattingly.pdf (2017)

Code Repositories

Multi-scale merge-split; a hierarchical sampling algorithm on multi-level graph partitions:
https://git.math.duke.edu/gitlab/gjh/multiscalemergesplit_codebase

Merge-split; a sampling algorithm on graph partitions:
https://git.math.duke.edu/gitlab/gjh/mergesplitcodebase

An optimal county clustering algorithm based on legal redistricting criteria:
https://git.math.duke.edu/gitlab/gjh/countycluster.git

Courses Taught

- MATH 493: Research Independent Study on Bayesian Methods to Evaluate School Report Cards (with Atsushi Hu; Fall 2020, Fall 2021)
- MATH 494: Research Independent Study on Bayesian Methods to Evaluate School Report Cards (with Atsushi Hu; Fall 2020, Fall 2021)
- MATH 490/790-95: Sampling: Theory and Practice (Spring 2021)
- IDS 798: Capstone Project (Spring 2020, Fall 2020, Spring 2021)
- MATH 202D: Multivariable Calculus for Economics (Fall 2020)
- MATH 230/730; STA 230: Probability (Fall 2019)
- MATH 390: Special Topics in Mathematics (Bass Connections on Gerrymandering) (Fall 2018, Spring 2019)
- MATH 393: Research Independent Study on Election Data Analysis (with Yashas Manjunatha; Spring 2019)
- MATH 353: Ordinary and Partial Differential Equations (Fall 2013, Fall 2014, Fall 2016(two sections), Fall 2017 (two sections))
- MATH 361S: Numerical Analysis (Spring 2016)
- MATH 431: Advanced calculus (Spring 2015)
- MATH 212: Multivariable calculus (Fall 2015)

Mentoring Activities

- Post-doc in Mathematics Eric Autrey on graph partition algorithms (Summer 2019 - present)
- Organized, facilitated and ran the Master's in Interdisciplinary Data Science Capstone projects: 18 projects and 39 students in the Spring of 2020, and 52 students and 17 projects in the 2020-21 accademic year. This includes actively engaging, guiding, and mentoring project teams throughout the program.
- Organized, facilitated and ran the Data+ program in the summer of 2020 and 2021. This includes actively engaging, guiding, and mentoring project teams throughout the program.
- Three Master's students in MIDS, Jaryl Ngan, Anshupriya Srivastava, and Ishan Gupta, on understanding the history of segregation in Durham Public Schools and effects of redistricting (2020-2021)
- Master's student Evan Wyse on non-reversible sampling methods in the context of sampling graph partitions (Fall 2019 - present)
- Undergraduate math major Atsushi Hu on a project examining Simpson's Paradox and Bayesian Inference within reporting School Quality; PRUV mentor and advisor for senior thesis (Summer 2020-Spring 2021)
- Doctoral student in Biomedical Engineering Daniel Puleri on lattice Boltzmann Methods (2018 - present)
- Post-doc in Mathematics Matthias Sachs on non-reversible skew detailed balance algorithms (2018 - 2020)

- Master's student in Biomedical Engineering Ismael Perez on lattice Boltzmann Methods (2018 - 2019)
- Mentored Onuoha Odim on a Public Policy undergraduate capstone project. The project was on racially polarized voting in Dallas, Texas, and lead to an undergraduate publication "Segregation and Integration in Dallas County" in DUJPPE Fall 2020 (Spring through Fall of 2019).
- Undergraduate computer science majors Luke Farrell and Jacob Schulman on undergraduate honors thesis around stratified sampling graph partitions related to quantifying gerrymandering; Supervisor (2018-2019).
- Undergraduate math major Claire Weibe on honor thesis concerning voting patterns and representation; committee member and mentor (2018-2019)
- Lead a Bass Connections course on understanding gerrymandering spanning the 2018-2019 accademic school year; involved 18 students and 4 research projects. (2018-2019)
- Master's student in Computer Science Elizabeth Margolin, a student of Ashwin Machanavajjhala, assisted with data analysis and algorithms for evaluating the effects of differential privacy on redistricting (2018-2019)
- High School students (at NCSSM) Daniel Carter, Zach Hunter on advance sampling algorithms (Summer 2019)
- High School students (at NCSSM) Daniel Carter, Zach Hunter, Olivia Fujikawa, and Sam Ferguson on optimal clustering algorithms, modelling how spatial patterns effect district representation, and advance sampling algorithms (2018-2019)
- Master's student in Statistics Lisa Libovich on analyzing redistricting in Maryland (2017-Summer 2018)

Presentations and Invited Talks

- Monte Carlo Methods for Revealing Gerrymandering. NYU Center for Data Science; Math & Democracy Seminar, December 2022.
- Quanityfing Gerrymandering. BU Mathematics and Statistics Colloquium, Fall 2022.
- Uncovering Gerrymandering. CSU San Bernardino Mathematics Colloquium, March 2021.
- Voting: The Struggle for Voice in American Politics. Virtual. Kavli Frontiers in Science NSF. July 3, 2020
- County Preservation. TRIPODS Redistricting Conference, Durham, NC. Duke University. March 4, 2020
- Duke Law School Lunch. Duke Law School. October 2, 2019
- Supreme Court Lunch. UNC Law School. July 1, 2019
- Quantifying Gerrymandering. Florida State University Department of Mathematics. Florida State University. February 5, 2019
- Quantifying Gerrymandering: Separating Natural Bias from Political Bias. Political Science Department. University of Delaware. October 4, 2018

- Quantifying Gerrymandering: Sampling the Space of Redistricting Plans. Mathematics Department. University of Delaware. October 3, 2018
- GPU Data Access on Complex Geometries for D3Q19 Lattice Boltzmann Method. Vancouver, BC. IEEE. May 1, 2018
- GPU Data Layouts for D3Q19 Lattice Boltzmann Methods. University of North Carolina At Chapel Hill. March 4, 2018
- Using GIS tools to understand the space of political redistricting plans. Duke Computer Science Department. November 3, 2017
- Computational methods for sampling the space of redistricting plans. Duke University. November 3, 2017
- Quantifying Gerrymandering. Gross Hall. Information Initiative at Duke. October 1, 2017
- Introduction to Computing with GPUs. Physics Building. Mathematics Department at Duke University. April 6, 2017
- Continuum-atomistic computations for dendritic solidification. University of North Carolina Chapel Hill. August 1, 2013
- Continuum approximation of the chemical master equation. SIAM CSE, Boston. March 5, 2013
- Simulation of Solidification by Coupling of Phase Field and Microscopic Computations. ICIAM Vancouver. December 6, 2011
- Memory access patterns for Lattice Boltzmann methods on GPUs. Poster session at the Duke Research Computing Symposium. Duke University. January 2017

Public Appearances and Outreach

- Lecture on Gerrymandering in Ellen Veomett's undergraduate seminar. January 2021
- Claiming the Power of the Vote. Virtual. STEMEMPOWER; middle and high school students. July 3, 2020
- Quantifying Gerrymandering. Raleigh Charter High School. November 5, 2019
- Gerrymandering on trial: The case for fair maps. May 3, 2019
- Panelist at Measures of Gerrymandering. Tucson, AZ. University of Arizona. October 5, 2018
- Quantifying Gerrymandering Public Lecture. San Francisco, CA. University of San Francisco. March 4, 2018

Service to Profession

Event/Org Administration

Organizer. TRIPODS Redistricting Conference 2020. Duke University. March 2020

Organizer. TRIPODS Quantifying Gerrymandering 2019. Duke University. November 2019

Organizer. Minisymposium at SIAM-SEAS. University of North Carolina at Chapel Hill. March 2018

Organizer. Triangle Research Group Meetings (meets roughly once per month since 2018)

Member. Industrial Affiliates Coordinator between Pratt and iID Practicum.

Participant. DCI Math Cicles; meet weekly over Spring 2021 with a group of 5th grade students.

Academic and Administrative Activities of the University

Organizer of Data+ (2020 to present)

Masters in Interdisciplinary Data Science Capstone director (2020 to present)

Journals in which provided peer review since 2019

Applied Math Modeling
Physics of Fluids
Computer Physics Communications
Election Law Journal
Communications in Statistics - Theory and Methods
Statistics and Public Policy

Submitted Grant Proposals

Submitted NSF grant for Computational Mathematics titled "Sampling Graph Partitions: Algorithms, Geospatial Structure, and Fairness" in November of 2020 as a co-PI

Submitted NSF grant on Harnessing the Data Revolution (HDR): Institutes for Data-Intensive Research in Science and Engineering in November of 2020 as senior personnel

STATE OF NORTH CAROLINA

COUNTY OF WAKE

IN THE GENERAL COURT OF JUSTICE
SUPERIOR COURT DIVISION
No. 21 CVS 015426

NORTH CAROLINA LEAGUE OF CONSERVATION VOTERS, INC., *et al.*,

Plaintiffs,

COMMON CAUSE,

Plaintiff-Intervenor,

v.

REPRESENTATIVE DESTIN HALL, in his official capacity as Chair of the House Standing Committee on Redistricting, *et al.*,

Defendants.

STATE OF NORTH CAROLINA

COUNTY OF WAKE

IN THE GENERAL COURT OF JUSTICE
SUPERIOR COURT DIVISION
No. 21 CVS 500085

REBECCA HARPER, *et al.*,

Plaintiffs,

v.

REPRESENTATIVE DESTIN HALL, in his official capacity as Chair of the House Standing Committee on Redistricting, *et al.*,

Defendants.

HARPER PLAINTIFFS' SUBMISSION REGARDING PROPOSED REMEDIAL PLANS FOR COURT REVIEW

Pursuant to this Court's February 8, 2022 Order regarding the submission of remedial maps and its February 17 Order appointing special masters, *Harper* Plaintiffs respectfully submit this statement regarding the proposed remedial districting plans they are submitting to the Court today for North Carolina's congressional districts and the state Senate.

Because the General Assembly has enacted a remedial state House plan on a bipartisan basis, *Harper* Plaintiffs are not submitting any alternative remedial House plan for the Court's review. But *Harper* Plaintiffs are submitting proposed maps for Congress and the state Senate because—unlike the General Assembly's enacted remedial House map—the congressional and Senate maps enacted yesterday were forced through the General Assembly by Republicans, were passed on strict-party line votes. The General Assembly's remedial congressional and Senate maps are partisan gerrymanders that flout the Supreme Court's decisions in this case. *Harper* Plaintiffs will explain these maps' deficiencies more fully in their responsive submission due February 21. But, in short, the newly enacted congressional and Senate maps do not come close to meeting the partisan fairness and other key metrics identified by the Supreme Court, and those maps repeat key features that this Court and the Supreme Court found reflected partisan intent and effect, including the General Assembly's new congressional map once again divides the cities of the Piedmont Triad into three separate districts to dilute the voting power of Democratic voters there, with ripple effects throughout the map.

The following describes the process of creating *Harper* Plaintiffs' proposed remedial congressional and Senate plans, and provides key data and information about those plans, including the data and information specified in this Court's February 8 and February 17 Orders.

I. Proposed Remedial Congressional Plan

Harper Plaintiffs' proposed remedial congressional plan is a plan filed by Senator Jay Chaudhuri as Senate Bill 738 on October 28, 2021, during the initial 2021 redistricting process.[1] Senator Chaudhuri drew this plan at a public terminal during the legislative map-drawing process that eventually led to enactment of the now-invalidated plans. *Harper* Plaintiffs submit this plan as it was publicly filed, without alteration.

Harper Plaintiffs have submitted by email block equivalency files for this proposed remedial plan in .CSV format, as well as ESRI shapefiles, for each district and for the plan as a whole. Attached hereto as exhibits are the following documents associated with this plan:

- Color versions of the statewide map and all districts in .PDF format (Exhibit A). The statewide map is the official version filed publicly as part of Senate Bill 738 and available on the General Assembly's website. The individual district maps were produced using this statewide map.
- The official StatPack Report available on the General Assembly's website, which demonstrates the proposed plan's adherence to traditional non-partisan districting criteria, including population deviation, county splits, and incumbency (Exhibit B). As shown in Exhibit B, the proposed plan does not pair any incumbents expected to run for Congress in 2022.
- The official Compactness Report available on the General Assembly's website, further demonstrating the proposed plan's adherence to traditional non-partisan districting criteria (Exhibit C).

[1] *See* https://www.ncleg.gov/BillLookUp/2021/S738.

Harper Plaintiffs evaluated this proposed remedial plan using three measures of partisan fairness: the mean-median difference, the efficiency gap, and a partisan symmetry metric described below. *See Harper v. Hall*, No. 413PA21, Order ¶ 6 (N.C. Feb. 4, 2022). Each of these metrics was calculated using the results of 16 recent statewide elections: 2016 Attorney General, 2016 Governor, 2016 Lieutenant Governor, 2016 Presidential, 2016 U.S. Senate, 2020 State Auditor, 2020 Attorney General, 2020 Commissioner of Agriculture, 2020 Commissioner of Insurance, 2020 Commissioner of Labor, 2020 Governor, 2020 Lieutenant Governor, 2020 Presidential, 2020 Secretary of State, 2020 Treasurer, and 2020 U.S. Senate.

Using this set of statewide elections, the partisan symmetry of *Harper* Plaintiffs' proposed remedial congressional plan is **0.36875 seats**, which, as explained further below, reflects the average deviation in seats won between the parties given a particular vote share. This score reflects an exceptionally high degree of partisan symmetry. By way of comparison, only 62 of Dr. Mattingly's 80,000 simulated congressional plans both accounted for incumbency and had a partisan symmetry score of less than 0.36875 seats.

In measuring partisan symmetry, *Harper* Plaintiffs' overriding goal was to ensure, as the Supreme Court directed, that "voters of all political parties" have "substantially equal opportunity to translate votes into seats across the plan." *Harper* Order ¶ 6. As the Supreme Court explained, "voters are entitled to have substantially the same opportunity to electing a supermajority or majority of representatives as the voters of the opposing party would be afforded if they comprised" a given percentage "of the statewide vote share in that same election." *Harper v. Hall*, No. 413PA21, slip op. ¶ 169 (N.C. Feb. 14, 2022). To implement this directive, *Harper* Plaintiffs' expert Dr. Jonathan Mattingly and his colleague Dr. Gregory Herschlag (the Phillip Griffiths Assistant Research Professor of Mathematics at Duke

University) measured partisan symmetry using a metric that uses *symmetric, reciprocal pairs* of Democratic vote shares across a range of recent, statewide elections and calculates how those two symmetric vote shares would translate into seats elected for that party in Congress.

To take an example: Dr. Mattingly and Dr. Herschlag began with the results of the 2016 Governor election and applied a "uniform swing" to the election results to reflect a 48% Democratic statewide vote share for that election. They calculated how many Republican representatives would be elected with that 48% Democratic vote share. They then applied a uniform swing to that election so that it reflected the corresponding, reciprocal Democratic vote share—*i.e.*, 52%. They then computed the number of *Democratic* representatives that would be elected with that 52% Democratic vote share. They then calculated the *absolute difference* between the number of Republican representatives elected with 48% Democratic vote share and the number of Democratic representatives elected with a 52% Democratic vote share. Thus, if 8 Republicans were elected with 48% Democratic vote share, and 7 Democrats were elected with 52% vote share, the absolute difference would be *1 seat*. (Because the figure is absolute, the value is always positive. It does not reflect which party benefits from the asymmetry; it captures only the *degree* of asymmetry.) Dr. Mattingly and Dr. Herschlag repeated that process using several sets of reciprocal vote fractions—45% and 55%, 46% and 54%, 47% and 53%, and 49% and 51%. They did this for each of the 16 statewide elections listed above, and then calculated an *average* of the absolute difference between the number of Republican seats elected (under the lower Democratic vote share) and the number of Democratic seats elected (under the higher Democratic vote share).

The metric thus captures the *average, absolute deviation*, across elections and across vote shares, between the number of seats that the two parties are expected to elect at the same given

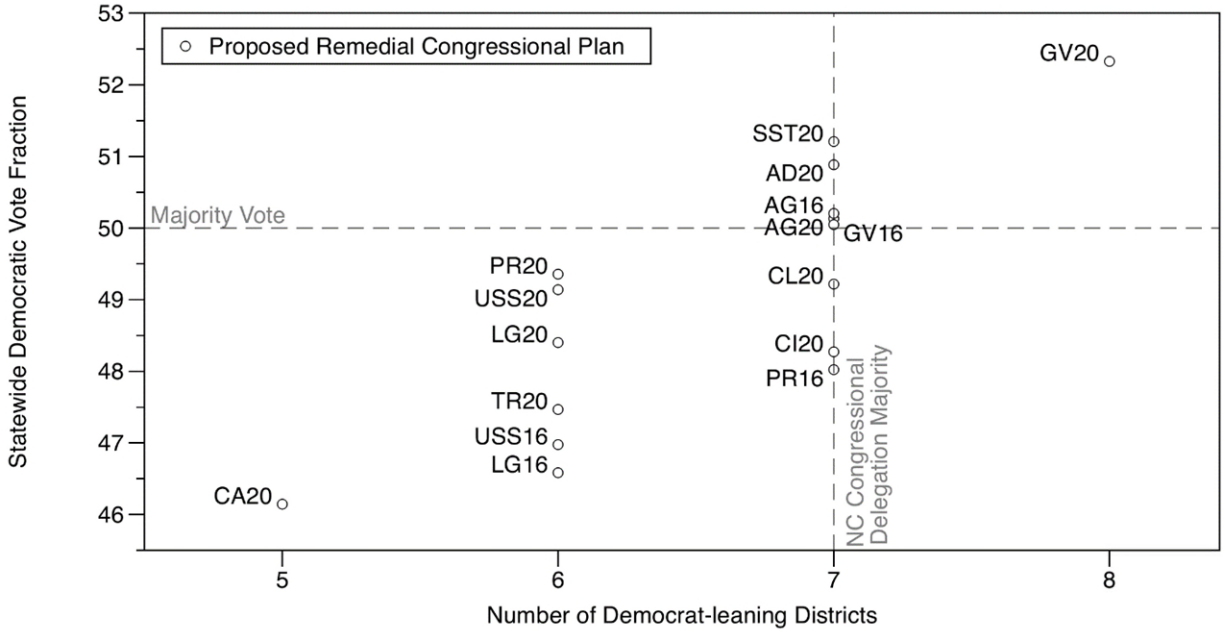
vote share. *Lower* numbers reflect *greater* partisan symmetry, and in particular, reflect a more "equal opportunity to electing a supermajority or majority of representatives as the voters of the opposing party would be afforded if they comprised" a given percentage "of the statewide vote share in that same election." *Harper* slip op. ¶ 169. As mentioned, the partisan symmetry metric for this proposed congressional plan is a deviation of 0.36875 seats. In practical terms, this means that for any given statewide election, the number of Democratic and Republican seats elected at a given party vote fraction will more often than not be the same number; and the expected difference averaged across a range of 16 statewide elections is only 0.36875 seats. As noted above, this is an exceptionally high degree of partisan symmetry.

As to other partisan fairness metrics identified in the Supreme Court's order and opinion: The average mean-median difference for this proposed map is **0.4504%**. The average efficiency gap using historical election results, without applying any uniform swing to these results, is **2.6676%**. The average efficiency gap calculated by conducting uniform swings on these election results, ranging from 45% to 55% Democratic vote share, is **2.7180%**.

The plot below illustrates this plan's extraordinary partisan fairness. IT shows the expected number of Democratic seats using the results of the 16 statewide elections listed above. For example, under the 2020 Lieutenant Governor race, which had a 48.4% Democratic vote share, Democrats would be expected to win 6 seats and Republicans would be expected to win 8 seats under the proposed map. In generally symmetric fashion, under the Governor 2020 race, which had a 52.32% Democratic vote share, Democrats would be expected to win 8 seats and Republicans would be expected to win 6 seats. Further demonstrating the symmetry of the plan, in elections where Republicans get 50% of the vote or more, they win 7 or 8 seats (or 9, in the election where they won 54% of the vote); similarly, in elections where Democrats get 50% of

the vote or more, they win 7 seats (or 8, in the election where they got 52.5% of the vote). In short, this is the partisan symmetry the Supreme Court directed.

Harper Plaintiffs' proposed plan is dramatically superior to the now-invalidated 2021 enacted Congressional plan on the metrics that the Supreme Court identified. The 2021 enacted congressional plan, using Dr. Mattingly and Dr. Herschlag's partisan symmetry metric, had a partisan symmetry score of 5.50625—meaning the average seat deviation between the parties given the same vote share was 15 times as high as it is in *Harper* plaintiffs' proposed remedial plan. This reflects that, under the enacted plan, Republicans win 10 seats when they get 51% of the vote, while Democrats win 4 seats when they get 51% of the vote—a highly asymmetric deviation of six seats. The 2021 enacted Congressional plan had a mean-median gap of 5.49%, and an enormous average efficiency gap of 18.267% (using historical election results) or 19.813% (by conducting uniform swing on those results). The proposed plan is also superior to the 2022 remedial congressional plan enacted by the General Assembly on party-line votes, as *Harper* Plaintiffs will detail in their February 21 filing.



II. Proposed Remedial Senate Plan

Harper Plaintiffs' proposed remedial Senate plan began with a base map selected from an ensemble generated by Dr. Jonathan Mattingly's computer algorithm, with a small number of adjustments aimed to (1) unpair incumbents where possible and (2) improve compactness.

The initial base map was selected from Dr. Mattingly's ensemble of simulations as follows: Dr. Mattingly began with a full ensemble of approximately 80,000 computer-generated Senate plans. Dr. Mattingly created this ensemble in connection with his academic work, prior to being retained as an expert in this case. All of the simulated plans in the ensemble follow traditional redistricting criteria that the Supreme Court described, including improving compactness and limiting the number of county splits. This ensemble did not seek to minimize municipality splits, which was not one of the criteria that the Supreme Court identified as potentially justifying deviations from partisan symmetry. *See Harper* Order ¶ 8 (listing compactness, equal population, preserving counties, and contiguity). The algorithm also did not restrict the county groupings to those used in the now-invalidated 2021 enacted Senate plan. Rather, the computer-generated plans in the ensemble could use any county groupings that comply with the Whole County Rule and *Stephenson*.

Dr. Mattingly and Dr. Herschlag then filtered this full ensemble of plans using metrics of partisan fairness, to ensure that any plan ultimately selected from the ensemble would strictly comply with the Supreme Court's directives. They used two filtering mechanisms: the first referred to as the "majority vote, majority seats" ratio, and the second being the same "partisan symmetry" metric described above in the context of the proposed congressional plan. For each map, the "majority vote, majority seats" ratio was calculated for each party as follows: Dr. Mattingly and Dr. Herschlag began with the results of the recent, statewide elections listed

above; counted the number of those elections where Democrats won the majority of the *seats* under that map; and divided that number by the number of elections where Democrats won a majority of the *vote*. That division produces a ratio representing the proportion of elections in which, when Democrats won a majority of the vote, they also won a majority of seats. For example, a Democratic "majority votes, majority seats" ratio of 0.75 would mean that, in 75% of the elections where the Democrats won a majority of the votes, Democrats won a majority of seats in the Senate. They then calculated the corresponding ratio for the Republicans.

Dr. Mattingly and Dr. Herschlag filtered the plans in the ensemble to require a "majority votes, majority seats" ratio exceeding 0.99 for both parties—*i.e.*, a plan was filtered out unless the party winning a majority of votes won a majority of seats over 99% of the time. Plans also were filtered to require a partisan symmetry score (as described above) of less than 0.85 seats.

This filtering process yielded a small subset of 15 potential Senate plans—less than 0.02% of the approximately 80,000 in the full ensemble. Among this subset, the base map chosen scored among the two best across each of the partisan fairness metrics and in terms of compactness. As noted, the ensemble from which this map was selected was not restricted to the county groupings used by the General Assembly in the now-invalidated 2021 enacted Senate plan. The base map varied from that now-invalidated map in three of the four clusters where there was a choice of county groupings under the Whole County Rule and *Stephenson*—specifically, for the Northeastern county clusters and the clusters containing Forsyth County and Buncombe County.

A small number of changes were then made to the base map exclusively for two purposes: to unpair all incumbents who can be unpaired consistent with the map's county-cluster boundaries, and to improve the map's compactness. In addition to *Harper* Plaintiffs' counsel, the

other individuals who participated in making the changes were John Holden, a GIS expert who served as *Harper* Plaintiffs' consulting expert during the merits phase of this case, and, with respect to certain changes, *Harper* Plaintiffs' testifying expert Dr. Christopher Cooper.

In particular, changes were made within four county groupings where it was possible to unpair incumbents: (1) Alamance-Anson-Cabarrus-Montgomery-Randolph-Richmond-Union; (2) Forsyth-Yadkin; (3) Iredell-Mecklenburg; (4) Guilford-Rockingham. Further changes were made in the Granville-Wake grouping to equalize population, given that Dr. Mattingly's ensemble did not permit splitting VTDs and splitting VTDs is necessary to get to 5% deviation in this cluster. Other changes were made to improve compactness in the Cumberland-Moore and Durham-Chatham county groupings. The proposed plan ultimately pairs incumbents in four clusters, all of which are unavoidable under the Whole County Rule: Alamance-Anson-Cabarrus-Montgomery-Randolph-Richmond-Union; Catawba-Cherokee; Carteret-Chowan: and Hoke-Scotland-Robeson. (The Alamance cluster had previously paired three incumbents under the base map.)

In making changes to the base map, conscious choices were made to avoid any changes that would alter the partisan makeup, with one exception: in the Guilford-Rockingham county grouping, the base map created three Democratic-leaning districts. The changes necessary to unpair Senator Berger and Senator Robinson replaced one of those Democratic-leaning districts with a competitive-to-Republican-leaning district. In other words, the only change to the base map that had partisan effects favored the Republican Party.

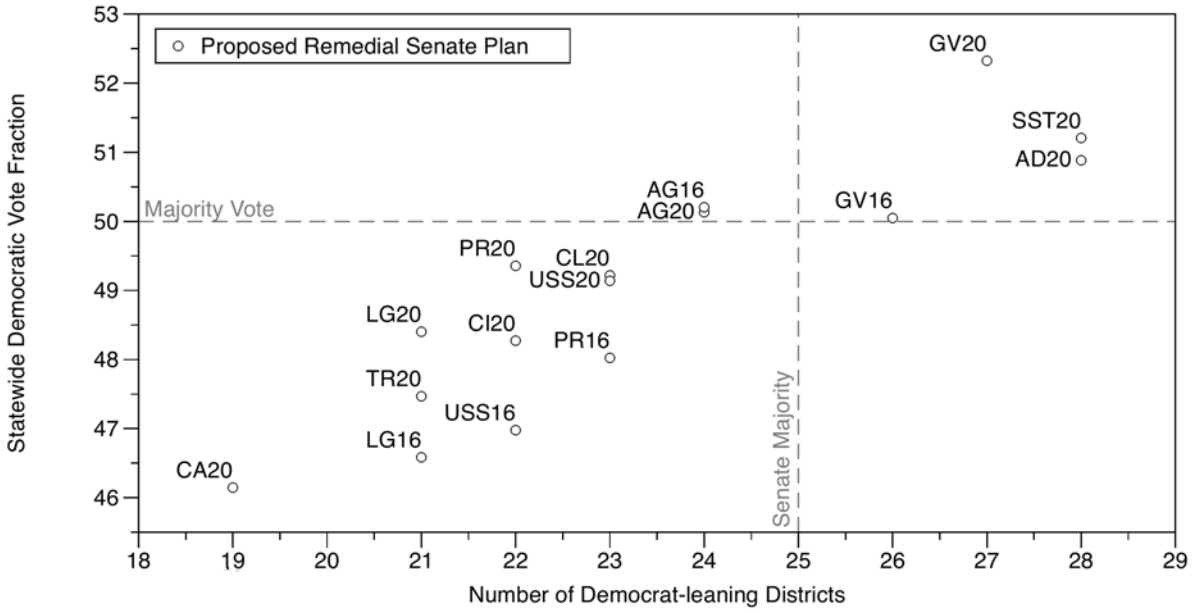
Harper Plaintiffs have submitted by email block equivalency files for this proposed plan in CSV format, as well as ESRI shapefiles, for each district and for the plan as a whole. *Harper* Plaintiffs also have attached as exhibits color versions of the statewide map (Exhibit D) and

maps of each county grouping (Exhibit E) in PDF format.[2] *Harper* Plaintiffs are also submitting spreadsheets identifying county splits and listing the population and population deviation in each district in the proposed plan. These spreadsheets confirm that the plan complies with the Whole County Rule and the equal population requirements. The average Reock score for the proposed plan is 0.414627, and the average Polsby-Popper score is 0.349573.

Harper Plaintiffs have also evaluated this proposed plan using the same measures of partisan fairness described above in the context of their proposed congressional plan: mean-median difference, efficiency gap, and partisan symmetry. *See Harper* Order ¶ 6. Using the same set of statewide elections listed above, the average mean-median difference for this proposed map is **0.2278%**. The average efficiency gap using historical election results, without applying any uniform swing to these results, is **1.9817%**. The average efficiency gap calculated by conducting uniform swings on these election results, ranging from 45% to 55% Democratic vote share, is **1.9551%**.

The partisan symmetry metric—*i.e.*, the average deviation in seats won at a given party vote share—is **1.04375 seats**. That compares to an average seat deviation in the 2021 enacted Senate plan, using the same metric, of 7.54 seats. The plot below, akin to the plot described above for the proposed congressional plan, further illustrates the plan's partisan fairness, showing the number of Democratic seats elected under the results of 16 recent statewide elections.

[2] Because *Harper* Plaintiffs did not assert any race-based claims in this litigation, they have not submitted any analysis of whether Section 2 of the Voting Rights Act requires the drawing of a majority-minority district.



The proposed plan is dramatically superior to the 2021 enacted Senate plan on the metrics that the Supreme Court identified. The 2021 enacted senate plan had enormous average seat deviations between the parties when they did the same in statewide elections, an average of over 7 seats. The 2021 enacted senate plan had a mean-median gap of 3.46%, an average efficiency gap of 7.192% (using historical election results) or 7.798% (by conducting uniform swing on those results). The proposed plan is also superior to the 2022 remedial Senate plan enacted by the General Assembly on party-line votes, as *Harper* Plaintiffs will detail in their February 21 filing.

Respectfully submitted, this the 18th day of February, 2022.

By:/s/ Narendra K. Ghosh

PATTERSON HARKAVY LLP

Burton Craige, NC Bar No. 9180
Narendra K. Ghosh, NC Bar No. 37649
Paul E. Smith, NC Bar No. 45014
100 Europa Dr., Suite 420
Chapel Hill, NC 27517
(919) 942-5200
bcraige@pathlaw.com
nghosh@pathlaw.com
psmith@pathlaw.com

Counsel for Harper Plaintiffs

ELIAS LAW GROUP LLP

Abha Khanna*
1700 Seventh Avenue, Suite 2100
Seattle, Washington 98101
Phone: (206) 656-0177
Facsimile: (206) 656-0180
AKhanna@elias.law

Lalitha D. Madduri*
Jacob D. Shelly*
Graham W. White*
10 G Street NE, Suite 600
Washington, D.C. 20002
Phone: (202) 968-4490
Facsimile: (202) 968-4498
LMadduri@elias.law
JShelly@elias.law
GWhite@elias.law

ARNOLD AND PORTER KAYE SCHOLER LLP

Elisabeth S. Theodore*
R. Stanton Jones*
Samuel F. Callahan*
601 Massachusetts Avenue NW
Washington, DC 20001-3743
(202) 954-5000
elisabeth.theodore@arnoldporter.com

Counsel for Harper Plaintiffs
* Admitted Pro Hac Vice

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a copy of the foregoing *by email*, addressed to counsel for all other parties.

This the 18th day of February, 2022.

_/s/ Narendra K. Ghosh _____
Narendra K. Ghosh, NC Bar No. 37649

Report on Remedial Districting Plans for North Carolina

Dr. Michael Barber
Brigham Young University
724 Spencer W. Kimball Tower
Provo, UT 84604
barber@byu.edu

Contents

1 Introduction and Qualifications

I have been asked by counsel for the Legislative Defendants to analyze the 2022 Remedial district plans for the North Carolina House, Senate, and Congressional districts recently passed by the North Carolina General Assembly. These were enacted as N.C. session laws 2022-2 (Senate, S744), 2022-3 (Congressional, S745), and 2022-4 (House, H980).

I analyze the plans by measuring each plan according to measures of partisan fairness suggested by the North Carolina Supreme Court. These measures are: the median-mean, efficiency gap, close-votes close-seats, and partisan symmetry. I also compute a partisan index based on 12 statewide elections used by one of Plaintiff's experts and present this index and the range of statewide election results for each district in each plan.

The results show that in all three plans (Congress, House, Senate), and across all measures, the Remedial plans exhibit extremely small degrees of bias and are significant improvements over the previous districts on these metrics.

I am an associate professor of political science at Brigham Young University and faculty fellow at the Center for the Study of Elections and Democracy in Provo, Utah. I received my PhD in political science from Princeton University in 2014 with emphases in American politics and quantitative methods/statistical analyses. My dissertation was awarded the 2014 Carl Albert Award for best dissertation in the area of American Politics by the American Political Science Association.

I teach a number of undergraduate courses in American politics and quantitative research methods.[1] These include classes about political representation, Congressional elections, statistical methods, and research design.

I have worked as an expert witness in a number of cases in which I have been asked to analyze and evaluate various political and elections-related data and statistical methods. Cases in which I have testified at trial or by deposition are listed in my CV, which is attached to the end of this report. I have previously provided expert reports in a number of

[1]The political science department at Brigham Young University does not offer any graduate degrees.

cases related to voting, redistricting, and election-related issues: *Nancy Carola Jacobson, et al., Plaintiffs, vs. Laurel M. Lee, et al., Defendants. Case No. 4:18-cv-00262 MW-CAS (U.S. District Court for the Northern District of Florida); Common Cause, et al., Plaintiffs, vs. Lewis, et al., Defendants. Case No. 18-CVS-14001 (Wake County, North Carolina); Kelvin Jones, et al., Plaintiffs, v. Ron DeSantis, et al., Defendants, Consolidated Case No. 4:19-cv-300 (U.S. District Court for the Northern District of Florida); Community Success Initiative, et al., Plaintiffs, v. Timothy K. Moore, et al., Defendants, Case No. 19-cv-15941 (Wake County, North Carolina); Richard Rose et al., Plaintiffs, v. Brad Raffensperger, Defendant, Civil Action No. 1:20-cv-02921-SDG (U.S. District Court for the Northern District of Georgia); Georgia Coalition for the People's Agenda, Inc., et. al., Plaintiffs, v. Brad Raffensberger, Defendant. Civil Action No. 1:18-cv-04727-ELR (U.S. District Court for the Northern District of Georgia); Alabama, et al., Plaintiffs, v. United States Department of Commerce; Gina Raimondo, et al., Defendants. Case No. CASE NO. 3:21-cv-00211-RAH-ECM-KCN (U.S. District Court for the Middle District of Alabama Eastern Division); League of Women Voters of Ohio, et al., Relators, v. Ohio Redistricting Commission, et al., Respondents. Case No. 2021-1193 (Supreme Court of Ohio); Adams, et al., Relators, v. DeWine, et al., Respondents. Case No. 2021-1428 (Supreme Court of Ohio)*

In my position as a professor of political science, I have conducted research on a variety of election- and voting-related topics in American politics and public opinion. Much of my research uses advanced statistical methods for the analysis of quantitative data. I have worked on a number of research projects that use "big data" that include millions of observations, including a number of state voter files, campaign contribution lists, and data from the US Census. I have also used geographic information systems and other mapping techniques in my work with political data.

Much of this research has been published in peer-reviewed journals. I have published nearly 20 peer-reviewed articles, including in our discipline's flagship journal, *The American Political Science Review* as well as the inter-disciplinary journal, *Science Advances*. My CV,

which details my complete publication record, is attached to this report as Appendix A.

The analysis and opinions I provide in this report are consistent with my education, training in statistical analysis, and knowledge of the relevant academic literature. These skills are well-suited for this type of analysis in political science and quantitative analysis more generally. My conclusions stated herein are based upon my review of the information available to me at this time. I reserve the right to alter, amend, or supplement these conclusions based upon further study or based upon the availability of additional information. I am being compensated for my time in preparing this report at an hourly rate of $400/hour. My compensation is in no way contingent on the conclusions reached as a result of my analysis. The opinions in this report are my own, and do not represent the view of Brigham Young University.

2 Data and Methods

Across all three plans (Congress, House, Senate) I rely upon election data from 12 statewide elections from 2016-2020. Specifically, I use the 2016 Lieutenant Governor and US Presidential races and the 2020 Commissioner of Agriculture, Treasurer, Lieutenant Governor, US Senate, Commissioner of Labor, US President, Attorney General, Auditor, Secretary of State, and Governor races. These are the same 12 elections used by Dr. Mattingly in his original expert report for his county cluster by county cluster analysis.

3 Congressional Plan

3.1 Partisan Lean of Districts

To measure the expected seat share in the remedial Congressional plan, I compute a partisan index of statewide elections for the 12 statewide partisan elections between 2016-2020 noted above. The index is simply the average of the two-party vote share for all 12

elections. In other words, if a district has an index value of 0.51, this would mean that 51% of the votes cast for the two major parties across these 12 elections went to Democratic candidates. Figure 1 shows this value for each of the 14 Congressional seats. Districts are ordered from least Democratic-leaning at the bottom to most Democratic-leaning at the top. Districts with a partisan index less than 0.50 (i.e. Republican-leaning) are shown as squares and districts with a partisan index greater than 0.50 (i.e. Democratic-leaning) are displayed as triangles.

Of the 14 Congressional districts there are 8 districts with an index less than 0.50 (Republican-leaning, shown as squares) and 6 districts with an index greater than 0.50 (Democratic-leaning shown as triangles). A vertical dashed line is placed at 0.50 in the figure for reference. In the now-enjoined 2021 Enacted Congressional plan there were 10 Republican-leaning districts and 4 Democratic leaning districts.

The grey horizontal lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. As can be seen by the width of the grey horizontal bars in each district, there is substantial variation across the 12 elections. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. I call these districts safely partisan since in all 12 of the statewide races the same party won a majority of votes. Districts where the grey horizontal lines cross the 0.50 vertical line indicate districts where both parties have won a majority of the votes in that district. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

Looking at the range across the index, there are 6 districts colored red (reliably Republican) in the figure, 4 blue districts (reliable Democratic), and 4 green districts (competitive) in the Congressional map. Using an alternative definition of competitiveness based on the closeness of the index to 0.50, there are 6 districts with an index less than 0.48, 4

districts between 0.48 and 0.52 (a commonly used range to define hyper-competitive seats), and 4 districts with an index of greater than 0.52.

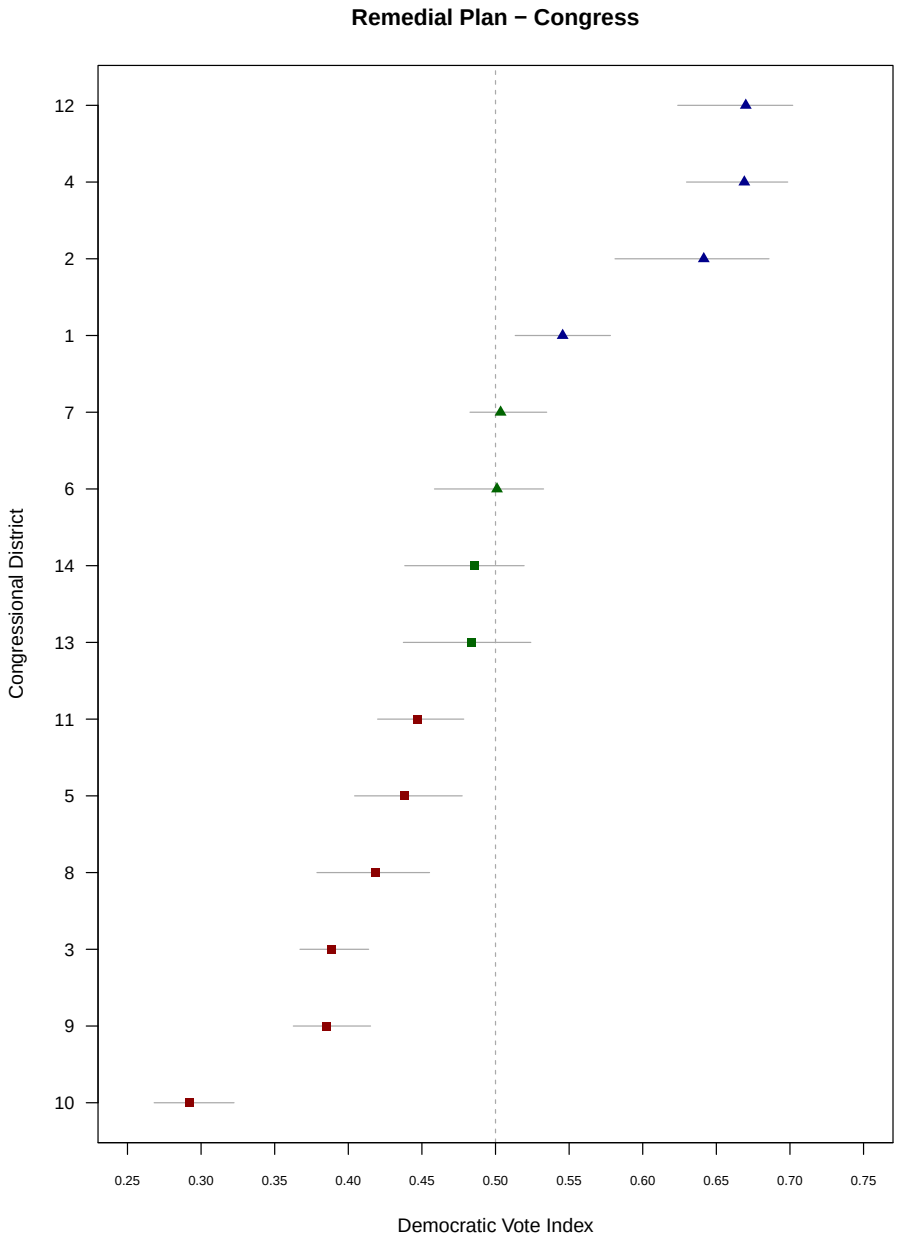


Figure 1: **Partisan Index of Congressional Districts in 2022 Remedial plan:** Partisan Index based on the average of 12 statewide partisan races between 2016-2020. Districts with a partisan index less than .50 (i.e. Republican leaning) are shown as squares and districts with a partisan index greater than .50 (i.e. Democratic leaning) are displayed as triangles. A vertical dashed line is placed at .50 in each panel for reference. The grey lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

3.2 Measures of Partisan Bias

In its ruling, the Court makes reference to four different measures of partisan bias, based on the analysis, reports, and testimony put forward by various experts during the trial. While scholars of these metrics note their limitations and drawbacks, for purposes of this report I assume their usefulness in light of the Court's decision.[2] Thus, I will consider each of these measures of partisan bias for the Congressional plan.

3.3 Median-Mean Measure

Academic literature describes the median-mean measure as being useful to measure the partisan bias of a districting plan.[3] The median-mean measure is calculated by taking the median value of the partisan index across all 14 districts in a plan (the value for which half of the observations are smaller and half the observations are larger) and subtracting from that the mean partisan index (the simple average) of all of the districts from the median. Consider an example in which there are three districts in a plan with partisan indices of 0.91, 0.46, and 0.40. To find the median we look for the district for which there is one district larger and one district smaller (0.46 in this case). To find the mean, we take the average by dividing the sum of the partisan indices by the number of districts. In this case, (0.91+0.46+0.40)/3 = 0.59. The median-mean value would then be 0.46-0.59 = -0.13. As in this example I take the Democratic vote share of the median district minus the mean

[2]Stephanopoulos, Nicholas O., and Eric M. McGhee. "Partisan gerrymandering and the efficiency gap." U. Chi. L. Rev. 82 (2015): 831.
Best, Robin E., Shawn J. Donahue, Jonathan Krasno, Daniel B. Magleby, and Michael D. McDonald. "Considering the prospects for establishing a packing gerrymandering standard." Election Law Journal 17, no. 1 (2018): 1-20.
McGhee, Eric. "Rejoinder to 'Considering the prospects for establishing a packing gerrymandering standard'." Election Law Journal 17, no. 1 (2018): 73-82.

[3]See Best, Robin E., Shawn J. Donahue, Jonathan Krasno, Daniel B. Magleby, and Michael D. McDonald. "Considering the prospects for establishing a packing gerrymandering standard." Election Law Journal 17, no. 1 (2018): 1-20. Warrington, Gregory S. "A comparison of partisan-gerrymandering measures." Election Law Journal: Rules, Politics, and Policy 18, no. 3 (2019): 262-281.
Wang, Samuel S-H. "Three tests for practical evaluation of partisan gerrymandering." Stan. L. Rev. 68 (2016): 1263. McDonald, Michael D., and Robin E. Best. "Unfair partisan gerrymanders in politics and law: A diagnostic applied to six cases." Election Law Journal 14, no. 4 (2015): 312-330.

Democratic vote share for all 14 districts in the Remedial plan. Negative numbers indicate a districting plan that favors Republicans and positive numbers indicate a slant in favor of Democrats.

Using the 12 statewide elections described above, the proposed remedial Congressional map has a median-mean value of -0.61%. This value is within the ±1% standard outlined by the court's ruling. Using the same data and method, the now-enjoined 2021 Enacted Congressional plan had a median-mean measure of -5.97%.

3.4 Efficiency Gap Measure

The efficiency gap is another redistricting metric discussed by academics and is similar to the median-mean measure in that it looks for the degree to which a political party's votes statewide are translated into seats in each district.[4] A description of this measure provided by the Brennen Center for Justice summarizes it: "[T]he efficiency gap counts the number of votes each party wastes in an election to determine whether either party enjoyed a systematic advantage in turning votes into seats. Any vote cast for a losing candidate is considered wasted, as are all the votes cast for a winning candidate in excess of the number needed to win."[5] In other words, under the efficiency gap the ideal strategy for a political party to maximize the impact of their voters is to distribute them as evenly as possible across districts so as to win by a narrow margin in the districts they win and lose by very large margins in the districts where they lose. Put another way, under the theory of minimizing wasted votes, "win by a little, lose by a lot" is the ideal strategy for a party to maximize their impact of their voters.[6]

The Brennen Center provides a simple example of how the efficiency gap is calculated:

[4]McGhee, Eric. "Measuring efficiency in redistricting." Election Law Journal: Rules, Politics, and Policy 16, no. 4 (2017): 417-442. Veomett, Ellen. "Efficiency gap, voter turnout, and the efficiency principle." Election Law Journal: Rules, Politics, and Policy 17, no. 4 (2018): 249-263. Plener Cover, Benjamin. "Quantifying partisan gerrymandering: An evaluation of the efficiency gap proposal." Stan. L. Rev. 70 (2018): 1131.

[5]https://www.brennancenter.org/sites/default/files/legal-work/How_the_Efficiency_Gap_Standard_Works.pdf

[6]Of course, parties have other priorities and winning by a single vote might not be their ideal scenario in reality.

To understand how the efficiency gap works, consider a hypothetical state with 500 residents that is divided into five legislative districts, each with 100 voters. In the most recent election cycle, Democrats won Districts 1 and 2 by wide margins, while Republicans won Districts 3, 4, and 5 in closer races. Overall, Democratic candidates received 55 percent of the statewide vote but won just 40 percent of the legislative seats, while Republican candidates received 45 percent and won 60 percent of the seats. The table below shows the election results for each district.[7]

District	D votes	R Votes	Result
1	75	25	D wins
2	60	40	D wins
3	43	57	R wins
4	48	52	R wins
5	49	51	R wins
Total:	275	225	

Once we have the election results, the first step is to consider the number of "wasted votes" in each district. Because the Republican candidate in this example lost in District 1, all 25 of the votes cast for that candidates are wasted. The Democratic candidate in District 1 won, but by 24 more votes than would be necessary (since all that is needed is 51 votes to win). Thus, there are 24 wasted Democratic votes in this district. Taking the difference indicates that there was a net of 1 Republican wasted vote in this district.

The efficiency gap is then calculated as Efficiency Gap = (Total Democratic Wasted Votes - Total Republican Wasted Votes) / Total Votes.[8] In this example and in analyzing the remedial Congressional plan, I use the Democratic seat and vote margins which means that negative efficiency gap numbers indicate a districting plan that favors Republican voters and positive numbers indicate a plan that favors Democratic voters.

Using the 12 statewide elections described above, the proposed remedial Congressional map has an efficiency gap value of -5.29%. This value is within the ±7% standard outlined by

[7] https://www.brennancenter.org/sites/default/files/legal-work/How_the_Efficiency_Gap_Standard_Works.pdf

[8] See McGhee, Eric. "Measuring efficiency in redistricting." Election Law Journal: Rules, Politics, and Policy 16, no. 4 (2017): 417-442.

the court's ruling. Using the same data and method, the now enjoined Enacted Congressional plan had a efficiency gap measure of -19.51%.

3.5 Close Votes, Close Seats

The court makes reference to "Dr. Duchin's close-votes-close-seats" analysis and quotes the trial court's determination that a map should not "prevent Democrats from gaining a tie or a majority in the House" (paragraph 199). This measure of partisan fairness is less defined than the median-mean and efficiency gap, and I am not aware of any published work by Dr. Duchin or others that explicitly lays out the mathematical definition or technical components of this test. However, Dr. Duchin describes the general idea in her initial expert report submitted in this case where she states, "The numerical notions of partisan fairness all tend to agree on one central point: an electoral climate with a roughly 50-50 split in partisan preference should produce a roughly 50-50 representational split. I will call this the Close-Votes-Close-Seats principle" (pg. 4, Duchin Report). She goes on to state, "[Close-Votes-Close-Seats] is closely related to the principle of Majority Rule: a party or group with more than half of the votes should be able to secure more than half of the seats. In fact, Close-Votes-Close-Seats is essentially a corollary (or byproduct) of Majority Rule. It is not practicable to design a map that always attains these properties, but by contrast a map that consistently thwarts them should be closely scrutinized and usually rejected." (pg. 4, Duchin Report).

In another redistricting case in Pennsylvania, Dr. Duchin further describes how she would measure and display this concept. She states, "To illustrate Close-Votes-Close-Seats, Majority Rule, and other norms of partisan fairness, it is helpful to examine a plot that shows vote shares on one axis and seat outcomes on the other. A plan can be overlaid with a vote pattern to see how the seat share relates to the vote share for that election. Repeating this across a range of different kinds of elections provides a robust view of the performance of the plan. Majority Rule, then, translates to the idea that the Southeast and Northwest

quadrants should be avoided" (pg. 14).[9]

With this in mind, Figure 2 produces the type of chart that Dr. Duchin describes. The left figure shows the results for the 2021 Enacted Congressional plan and the right panel shows the results for the 2022 Remedial Congressional plan. The horizontal axis of each chart measures the statewide vote share earned by the Democratic candidates for each of the 12 statewide elections discussed above. The vertical axis of each figure measure the proportion of districts where the Democratic candidate won a majority of the votes in that same election. In other words, this chart is measuring the degree to which statewide votes are translated to seats. Per Dr. Duchin's test, the "northwest" and "southeast" quadrants of this figure, colored in red, indicate outcomes that are anti-majoritarian, or places where a party wins a majority of the votes statewide but those votes are not translated into a majority of the seats.[10]

In each figure there are 12 dots, one for each of the 12 statewide elections. We see that in the enjoined 2021 Enacted Congressional plan there are 4 points in the lower right panel representing anti-majoritarian outcomes. Furthermore, as one moves along the horizontal axis, the dots tend not to move upwards along the vertical axis, indicating a map that is not especially responsive to changes in voters' preferences.

The 2022 Remedial map is very different. Only 1 of the 12 points (Attorney General 2020) reside in the lower right quadrant where the Democratic candidate for office won a majority of the votes but those votes would not have translated into a majority of the seats. Notably, in this one election the Democratic candidate won with 50.13% of the vote.

All of the remaining 11 elections produce majoritarian outcomes where a majority of votes statewide translate into a majority of the seats for Congress. These are the dots in the lower left (southwest) and upper right (northeast) quadrants of the figure.

[9]https://www.pacourts.us/Storage/media/pdfs/20220216/190511-feb.14,2022-exceptionswithbriefinsupportincorporated(govwolf).pdf, retrieved Feb 16, 2022.

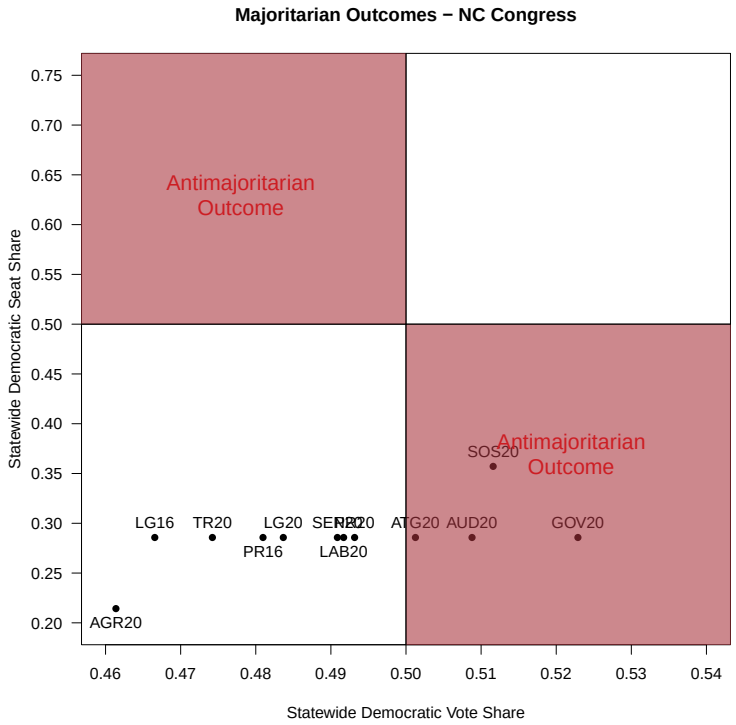
[10]It is important to note that when discussing "seats won" by a party, we are not discussing actual congressional or legislative election outcomes but rather whether the candidate for statewide office being considered, when their votes are disaggregated across the different legislative districts, won a majority of votes in each of those districts.

It is not expected that all of the points will fall outside of the red quadrants. As Dr. Duchin states, "It is not practicable to design a map that always attains these properties" (pg. 4, Duchin Report), however, the Remedial Congressional plan performs very well in that 11 of the 12 elections result in majoritarian outcomes.

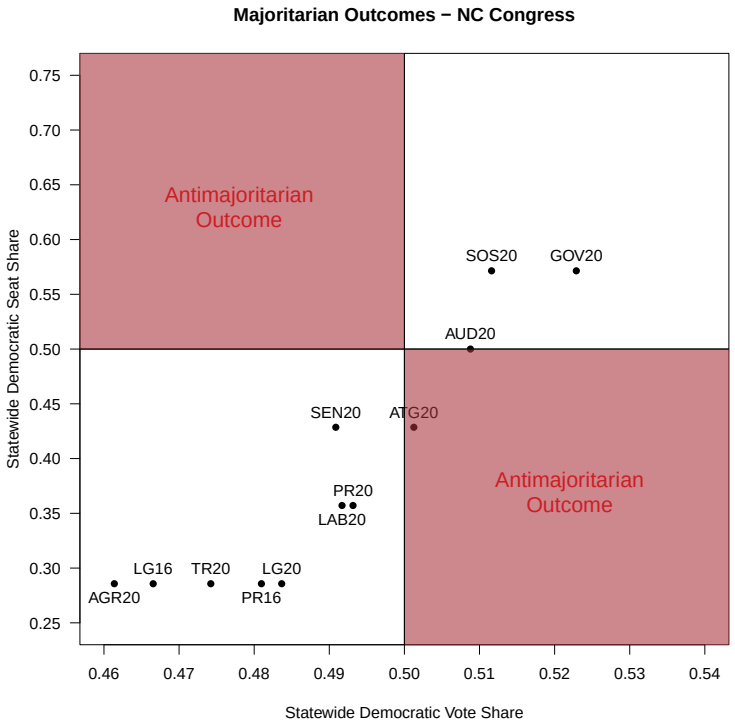
Furthermore, the points in the 2022 Remedial Congressional plan exhibit a general upward slope, meaning that as a party wins more votes statewide their share of the seats based on those votes tends to likewise increase. This indicates a map that is more responsive to changes in voters' preferences.

Figure 2: **Close-Votes-Close-Seats Analysis**

(a) 2021 Enacted Plan



(b) 2022 Remedial plan



Note: Each dot in the figure is a statewide election. The horizontal axis shows the Democratic vote share in each election. The vertical axis shows the proportion of districts that would be won when statewide votes are disaggregated across districts. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

3.6 Partisan Symmetry

According to academic literature, the idea behind the concept of partisan symmetry is to attempt to measure whether a redistricting plan treats both parties equally. In his expert report in this case, Dr. Chen discusses this concept, stating: "Another common measure of partisan bias is based on the concept of partisan symmetry and asks the following question: Under a given districting plan and given a particular election-based measure of district partisanship, what share of seats would each party win in a hypothetical tied election (i.e., 50% vote share for each of two parties)" (pg. 46). This statement illustrates one of the key ideas of the concept of partisan symmetry - how seats are distributed across the two political parties in a hypothetical election in which both political parties receive 50% of the votes.

The concept, however, can be extended beyond an analysis of a 50/50 tie. More broadly, the concept of partisan symmetry implies that a particular vote share for Party A that yields a particular seat share for Party A should, in turn, produce roughly the same result for Party B.[11] In other words, if Republicans win 53% of the statewide vote and obtain 60% of the seats in a chamber, then partisan symmetry would suggest that if Democrats were to win 53% of the statewide vote, they should also win 60% of the seats.[12]

A common way academic studies measure partisan symmetry is by producing a seats-votes curve generated by a uniform partisan swing.[13] The basic idea is to look at the vote share in each district and increase/decrease the vote share in each district by a uniform amount across a range of outcomes. As you do this, we note the change in the number of districts won/lost by a party. What this produces is a figure where the horizontal axis shows the statewide vote share across a range of value and the vertical axis shows the proportion of districts carried by a party for each of the vote shares. Each point then shows the

[11] Nagle, John F., and Alec Ramsay. "On measuring two-party partisan bias in unbalanced states." Election Law Journal: Rules, Politics, and Policy 20, no. 1 (2021): 116-138.

[12] It is often the case that the party that wins a majority of the votes wins more than their proportion of votes in seats. This is referred to as the "winners bonus."

[13] See https://www.amacad.org/news/redistricting-and-representation for an example and explanation by Dr. Duchin.

translation of statewide votes (horizontal axis) to the statewide proportion of seats (vertical axis). Connecting these points creates what is called a seats-votes curve.

Under the partisan symmetry measure, a symmetric plan should exhibit two properties. First, the seats-votes curve should cross, or be very close to, the point (0.5, 0.5), which would indicate a plan where 50% of the votes statewide yields 50% of the seats statewide. Of course, not all plans will perfectly cross this point, but the further a seats-votes curve is from the 50/50 point, the less symmetric the plan is. Furthermore, the seats-votes curve should increase and decrease at roughly the same rate on either side of the 0.50 value. In other words, as Democrats gain more votes statewide, the translation of those votes to seats should be similar to when Republicans gain an equally large share of the votes.

Figure 3 shows the seats-votes curve from a uniform partisan swing for the Congressional maps. The left panel shows this for the 2021 Enacted Congressional map and the right panel shows this for the 2022 Remedial Congressional map. It is immediately apparent that the 2021 Enacted Congressional map is less symmetric than the 2022 Remedial Congressional map.

Each figure notes two important statistics. The first, seat bias at 50% vote, indicates the distance between 50% of the seats and the predicted seat share when the both parties obtain 50% of the votes. In the 2021 Enacted plan this value is 21.4%, or three seats in the 14 district plan. In other words, in the enjoined 2021 Enacted Congressional plan when Democrats win 50% of the vote we would predict that they would win 28.6% of the seats (4/14). The 2022 Remedial Congressional plan is much improved by this measure. Now when Democrats win 50% of the vote is is predicted that they will win 42.8% of the seats (6/14).

The next statistic to note is the "vote bias for 50% of seats", which measures the proportion of the statewide vote that we would expect a party to need to win in order to obtain 50% of the seats. In the enjoined 2021 Enacted Congressional plan this is 5.9%. In other words, we would expect Democrats to have to win 55.9% of the statewide vote before

they would receive 50% of the 14 seats in the congressional delegation. This statistic is also much improved in the 2022 Remedial Congressional plan. Here the vote bias for 50% of seats is 0.6%, meaning that we would expect Democrats to win 7 out of the 14 seats for Congress when they obtain 50.6% of the statewide vote.

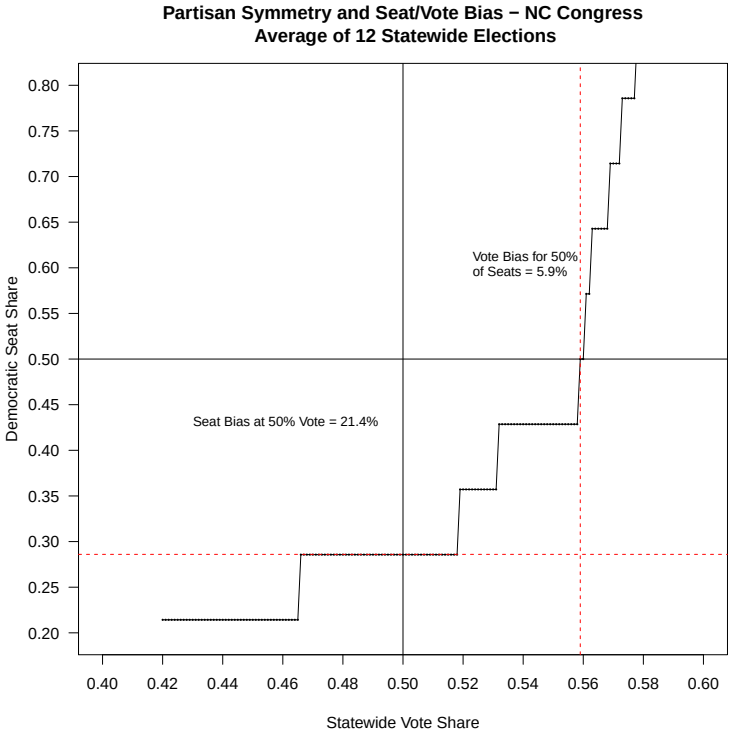
The final thing to note in the partisan symmetry analysis is the overall trajectory of the seats-votes curves in each plot. The 2022 Remedial Congressional plan moves in a much smoother and symmetric manner from the bottom left to top right quadrants of the figure. This is not the case in the 2021 Enacted Congressional plan. Here the line is much less symmetric in these two quadrants. In the bottom left quadrant the line is relatively flat while in the top right quadrant the line is relatively steep. This would indicate asymmetry in a plan whereas the line in the 2022 Remedial plan is much more symmetric.

4 Conclusion for Congressional Plan

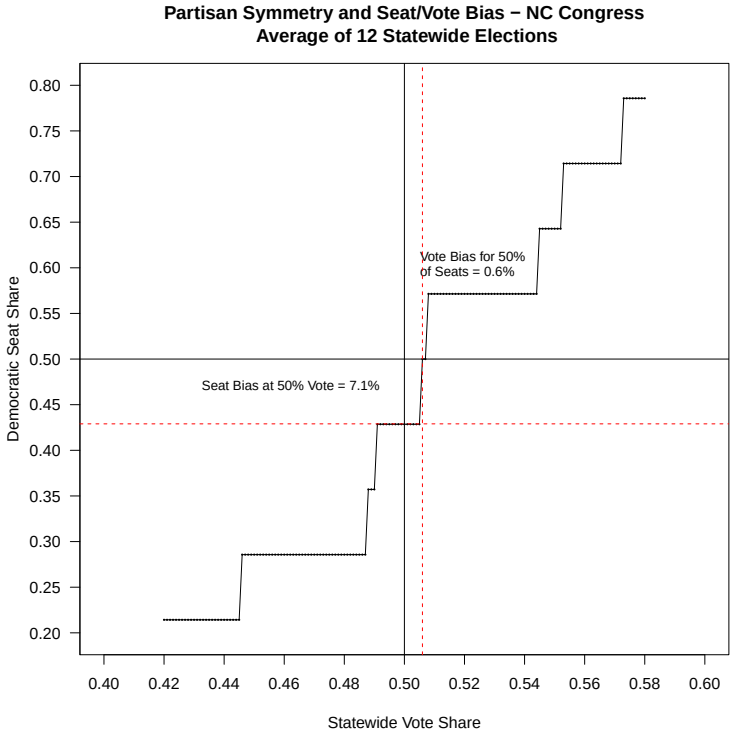
Overall, the 2022 Remedial plan for North Carolina's congressional districts is an improvement over the 2021 Enacted Congressional plan on the four measures outlined by the Court. The Remedial plan is within the Court's thresholds on the median-mean (-0.61%) and efficiency gap (-5.29%) measures. The plan produces majoritarian outcomes in 11 of the 12 elections considered in the close-votes-close-seats analysis and the plan is much more responsive and symmetric in the seats-votes curves that measure partisan symmetry.

Figure 3: **Partisan Symmetry Analysis**

(a) 2021 Enacted Plan



(b) 2022 Remedial plan



Note: The horizontal axis measures the statewide vote share from a uniform swing. The vertical axis shows the expected Democratic share of seats. The seats-votes curve shows the relationship between statewide vote shares and expected statewide seat shares. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

5 State House Plan

5.1 Partisan Lean of Districts

Figure 4 shows the partisan lean for each of the 120 seats in the 2022 Remedial House plan for the North Carolina House of Representatives. Districts are ordered from least Democratic-leaning at the bottom to most Democratic-leaning at the top. Districts with a partisan index less than 0.50 (i.e. Republican-leaning) are shown as squares and districts with a partisan index greater than 0.50 (i.e. Democratic-leaning) are displayed as triangles.

Of the 120 districts in the 2022 Remedial House plan, there are 63 districts with an index less than 0.50 (Republican-leaning, shown as squares) and 57 districts with an index greater than 0.50 (Democratic-leaning shown as triangles). A vertical dashed line is placed at 0.50 in the figure for reference. In the now-enjoined 2021 Enacted House plan there were 70 Republican-leaning districts and 50 Democratic leaning districts.

The grey horizontal lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. As can be seen by the width of the grey horizontal bars in each district, there is substantial variation across the 12 elections. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. I call these districts safely partisan since in all 12 of the statewide races the same party won a majority of votes. Districts where the grey horizontal lines cross the 0.50 vertical line indicate districts where both parties have won a majority of the votes in that district. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

Looking at the range across the index, there are 55 districts colored red (reliably Republican) in the figure, 42 blue districts (reliable Democratic), and 23 green districts

(competitive) in the House map. Using an alternative definition of competitiveness based on the closeness of the index to 0.50, there are 59 districts with an index less than 0.48, 12 districts between 0.48 and 0.52 (a commonly used range to define hyper-competitive seats), and 49 districts with an index of greater than 0.52.

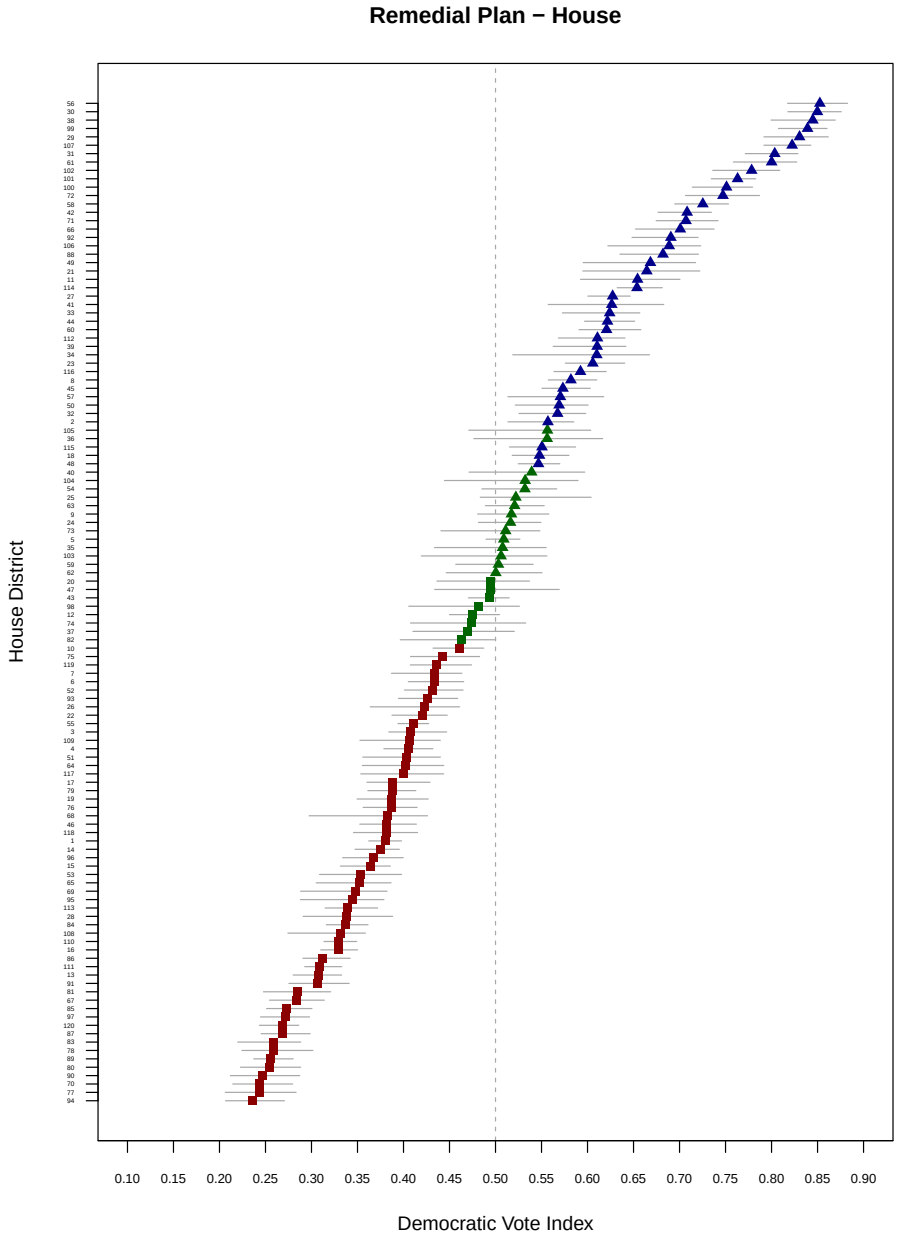


Figure 4: **Partisan Index of House Districts in 2022 Remedial plan:** Partisan Index based on the average of 12 statewide partisan races between 2016-2020. Districts with a partisan index less than .50 (i.e. Republican leaning) are shown as squares and districts with a partisan index greater than .50 (i.e. Democratic leaning) are displayed as triangles. A vertical dashed line is placed at .50 in each panel for reference. The grey lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

5.2 Median-Mean Measure

Using the 12 statewide elections described above, the proposed 2022 Remedial House map has a median-mean value of -0.70%. This value is within the ±1% standard outlined by the court's ruling. Using the same data and method, the 2021 Enacted House plan had a median-mean measure of -3.36%.

5.3 Efficiency Gap Measure

Using the 12 statewide elections described above, the proposed 2022 Remedial House map has an efficiency gap value of -0.84%. This value is within the ±7% standard outlined by the Court's ruling. Using the same data and method, the 2021 Enacted House plan had an efficiency gap measure of -7.16%.

5.4 Close Votes, Close Seats

Figure 5 shows the close-votes-close-seats analysis for both the 2021 now-enjoined and 2022 Remedial House plan. The left figure shows the results for the 2021 Enacted House plan and the right panel shows the results for the 2022 proposed Remedial House plan. The horizontal axis of each chart measures the statewide vote share earned by the Democratic candidates for each of the 12 statewide elections discussed above. The vertical axis of each chart measures the proportion of districts where the Democratic candidate won a majority of the votes in that same election. in other words, this chart is measuring the degree to which statewide votes are translated to seats. The "northwest" and "southeast" quadrants, colored in red, indicate outcomes that are anti-majoritarian, or places where a party wins a majority of the votes statewide but those votes are not translated into a majority of the seats.[14]

[14]It is important to note that when discussing "seats won" by a party, we are not discussing actual congressional or legislative election outcomes but rather whether the candidate for statewide office being considered, when their votes are disaggregated across the different legislative districts, won a majority of votes in each of those districts.

In each figure there are 12 dots, one for each of the 12 statewide elections. We see that in the 2021 Enacted House plan there are 4 points in the lower right panel representing anti-majoritarian outcomes. The 2022 Remedial House map is very different. Only 1 of the 12 points (Attorney General 2020) resides in the lower right quadrant where the Democratic candidate for office won a majority of the votes but those votes would not have translated into a majority of the seats. Notably, in this election the Democratic candidate won with only 50.13% of the vote.

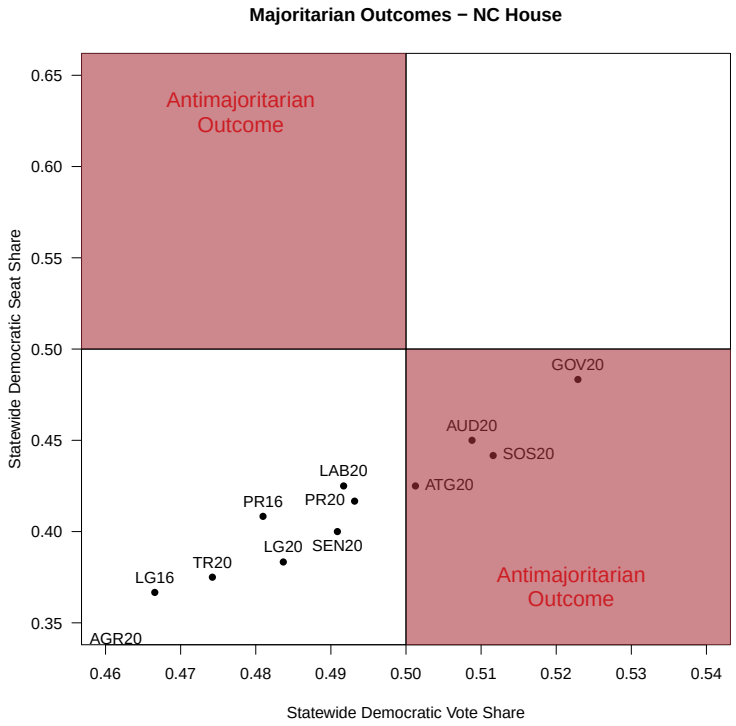
All of the remaining 11 elections produce majoritarian outcomes where a majority of votes statewide translate into a majority of the seats in the House. These are the dots in the lower left (southwest) and upper right (northeast) quadrants of the figure.

It is not expected that all of the points will fall outside of the red quadrants. As Dr. Duchin states, "It is not practicable to design a map that always attains these properties" (pg. 4, Duchin Report), however, the 2022 Remedial House plan performs very well in that 11 of the 12 elections result in majoritarian outcomes.

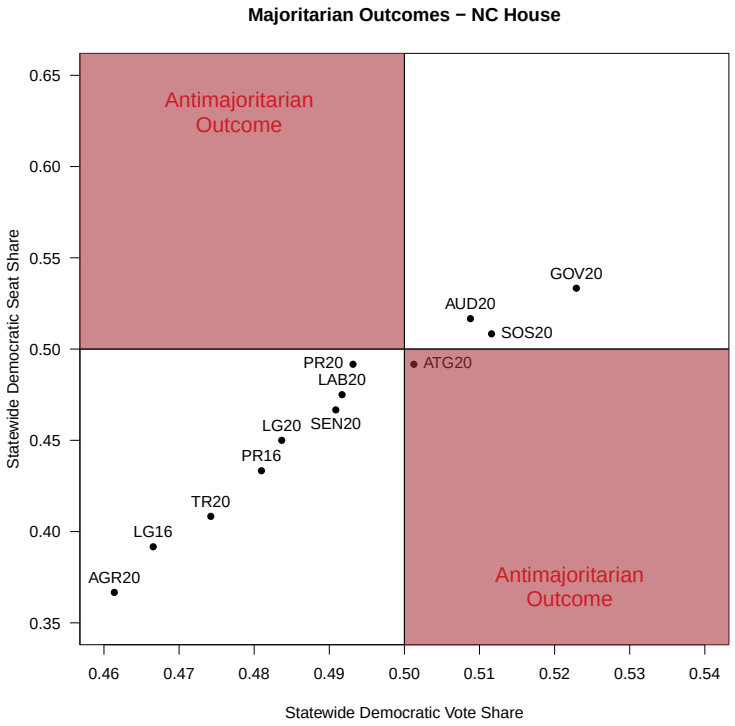
Furthermore, the points in the 2022 Remedial plan exhibit a general upward slope, meaning that as a party wins more votes statewide their share of the seats based on those votes tends to likewise increase. This indicates a map that is more responsive to changes in voters' preferences.

Figure 5: **Close-Votes-Close-Seats Analysis**

(a) 2021 Enacted Plan



(b) 2022 Remedial plan



Note: Each dot in the figure is a statewide election. The horizontal axis shows the Democratic vote share in each election. The vertical axis shows the proportion of districts that would be won when statewide votes are disaggregated across districts. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

5.5 Partisan Symmetry

Figure 6 shows the seats-votes curve from a uniform partisan swing for the state House maps. The left panel shows this for the 2021 Enacted House map and the right panel shows this for the 2022 Remedial House map. It is immediately apparent that the 2021 Enacted House map is less symmetric than the 2022 Remedial House map.

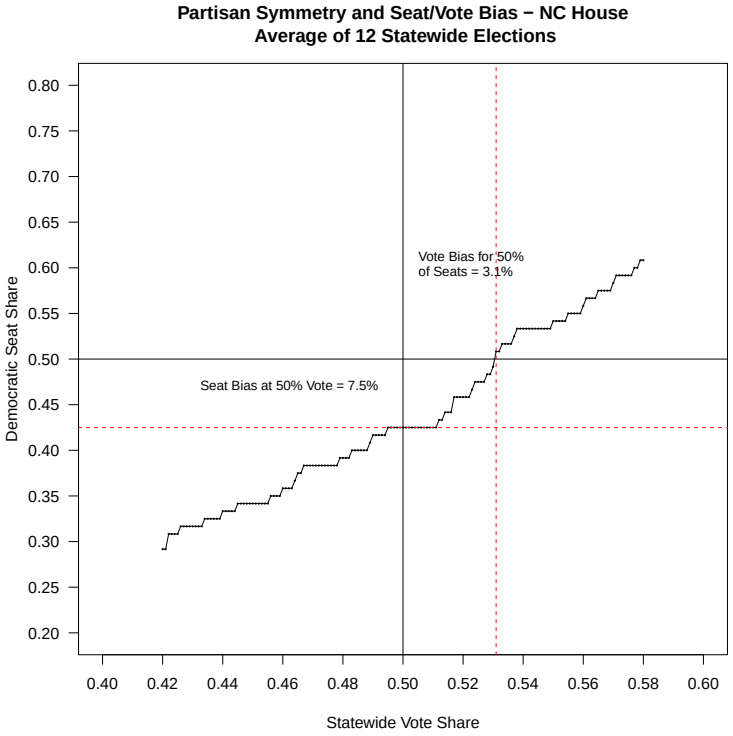
Each figure notes two important statistics. The first, seat bias at 50% vote, indicates the distance between 50% of the seats and the predicted seat share when the both parties obtain 50% of the votes. In the 2021 Enacted plan this value is 7.5%. In other words, in the 2021 Enacted House plan when Democrats win 50% of the vote we would predict that they would win 42.5% of the seats. The 2022 Remedial House plan is much improved on the partisan symmetry metric. Now when Democrats win 50% of the vote it is predicted that they will win 50% of the seats.

The next statistic to note is the "vote bias for 50% of seats", which measures the proportion of the statewide vote that we would expect a party to need to win in order to obtain 50% of the seats. In the 2021 Enacted House plan this is 3.1%. In other words, we would expect Democrats to have to win 53.1% of the statewide vote before they would receive 50% of the seats in the state House. This statistic is also much improved in the 2022 Remedial House plan. Here the vote bias for 50% of seats is -0.2%, meaning that we would expect Democrats to win 60 out of the 120 seats in the chamber when they obtain 49.8% of the statewide vote.

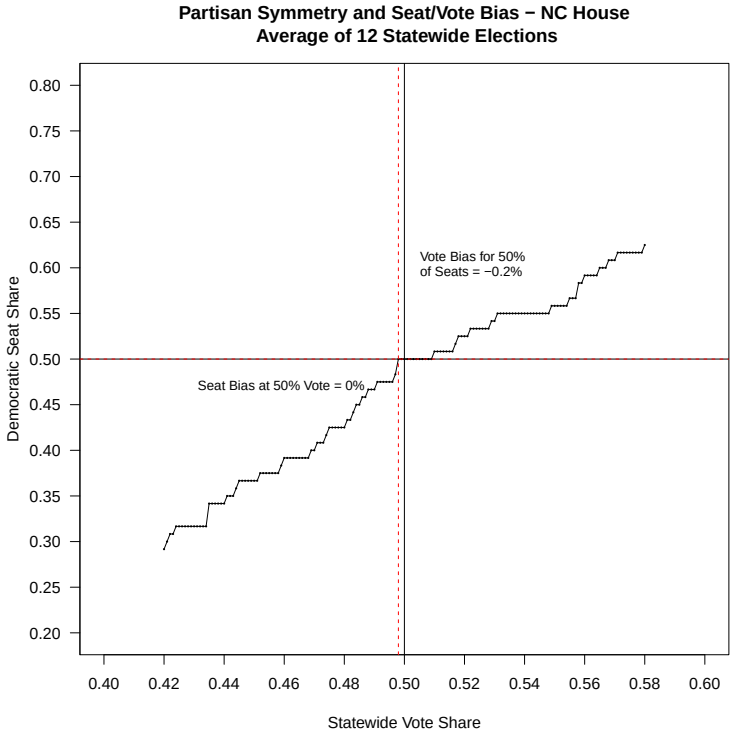
The final thing to note is the overall trajectory of the seats-votes curves in each plot. The 2022 Remedial House plan moves in a much smoother and symmetric manner from the bottom left to top right quadrants of the figure. This is not the case in the 2021 Enacted House plan, where the line is much less symmetric in these two quadrants. The 2022 Remedial House plan also passes exactly through the 50/50 point at the middle of the graph.

Figure 6: **Partisan Symmetry Analysis**

(a) 2021 Enacted Plan



(b) 2022 Remedial plan



Note: The horizontal axis measures the statewide vote share from a uniform swing. The vertical axis shows the expected Democratic share of seats. The seats-votes curve shows the relationship between statewide vote shares and expected statewide seat shares. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

5.6 Considerations of Race

During the trail court hearing various plaintiffs discussed the racial composition of House districts, the presence or absence of racially polarized voting, and the thresholds necessary for Black voters to elect the candidates of their choice. Table 1 below shows the Black voting age population percent for districts with Black incumbents for the districts used in the 2018 election cycle, the 2020 election cycle, the 2021 now-enjoined districts, and the 2022 Remedial plan.

6 Conclusion for North Carolina House Plan

Overall, the 2022 Remedial plan for North Carolina's state House districts is an improvement over the 2021 Enacted House plan on the four measures outlined by the Court. The Remedial House plan is within the Court's thresholds on the median-mean (-0.70%) and efficiency gap (-0.84%) measures. The plan produces majoritarian outcomes in 11 of the 12 elections considered in the close-votes-close-seats analysis and the plan is responsive and symmetric using the seats-votes curve to measure partisan symmetry.

Table 1: BVAP for House Districts with Black Incumbents

Incumbent	2018 District	2018 District %BVAP	Incumbent	2020 District	2020 District %BVAP	SL-2021-175 District	SL-2021-175 %BVAP	2022 Remedial District	2022 Remedial District %BVAP
Hunter	5	44.32%	Hunter	5	42.23%	5	38.59%	5	38.59%
Smith, K.	8	44.85%	Smith, K.	8	43.74%	8	45.45%	8	38.13%
Smith, R.	21	39.00%	Smith, R.	21	38.68%	10	34.27%	10	34.37%
Willingham	23	51.83%	Willingham	23	51.53%	23	53.41%	23	53.41%
Cooper-Suggs	24	38.11%	Cooper-Suggs	24	39.14%	24	37.52%	24	38.50%
Gailliard	25	40.73%	Gailliard	25	43.63%	25	41.00%	25	39.97%
Alston	29	37.49%	Alston	29	38.43%	29	39.58%	29	31.03%
Hawkins	31	49.56%	Hawkins	31	41.29%	31	39.72%	31	45.63%
Garrison	32	49.12%	Garrison	32	49.17%	32	43.24%	32	43.36%
Gill	33	44.18%	Gill	33	41.48%	33	30.91%	33	34.01%
Batch	37	14.34%							
Hulley	38	48.30%	Jones, A.	38	41.46%	38	45.44%	38	43.91%
			Roberson	39	37.83%	39	33.04%	39	33.65%
Lucas	42	42.23%	Lucas	42	40.97%	42	40.97%	42	41.97%
Floyd	43	49.96%							
Pierce	48	36.13%	Pierce	48	37.09%	48	37.09%	48	37.09%
Reives	54	15.74%	Reives	54	13.56%	54	11.60%	54	11.60%
Quick	58	42.66%	Quick	58	44.95%	58	44.65%	58	48.38%
Brockman	60	40.06%	Brockman	60	35.86%	60	36.15%	60	34.68%
Terry	71	36.56%	Terry	71	42.04%	71	41.19%	71	34.81%
Montgomery	72	47.51%	Baker, A.	72	35.76%	72	34.96%	72	40.46%
Beasley	92	30.16%	Brown	92	42.04%	92	40.82%	92	34.38%
Majeed	99	49.54%	Majeed	99	37.71%	99	48.91%	99	48.75%
Logan	101	50.82%	Logan	101	49.89%	101	48.79%	101	53.42%
Lofton	104	6.22%	Lofton	104	12.76%	104	9.10%	104	9.76%
Cunningham	106	38.00%	Cunningham	106	48.48%	106	45.47%	106	37.58%
Alexander	107	49.39%	Alexander	107	55.65%	107	49.16%	107	59.22%

Note: BVAP percents are "% any part Black."

7 State Senate Plan

7.1 Partisan Lean of Districts

Figure 7 shows the partisan lean based on the index of statewide elections for each of the 50 seats in the 2022 Remedial plan for the North Carolina Senate. Districts are ordered from least Democratic-leaning at the bottom to most Democratic-leaning at the top. Districts with a partisan index less than 0.50 (i.e. Republican-leaning) are shown as squares and districts with a partisan index greater than 0.50 (i.e. Democratic-leaning) are displayed as triangles.

Of the 50 districts there are 28 districts with an index less than 0.50 (Republican-leaning, shown as squares) and 22 districts with an index greater than 0.50 (Democratic-leaning shown as triangles). A vertical dashed line is placed at 0.50 in the figure for reference. In the now-enjoined 2021 Enacted plan there were 30 Republican-leaning districts and 20 Democratic leaning districts.

The grey horizontal lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. As can be seen by the width of the grey horizontal bars in each district, there is substantial variation across the 12 elections. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. I call these districts safely partisan since in all 12 of the statewide races the same party won a majority of votes. Districts where the grey horizontal lines cross the 0.50 vertical line indicate districts where both parties have won a majority of the votes in that district. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

Looking at the range across the index, there are 24 districts colored red (reliably Republican) in the figure, 18 blue districts (reliable Democratic), and 8 green districts (com-

petitive) in the House map. Using an alternative definition of competitiveness based on the closeness of the index to 0.50, there are 25 districts with an index less than 0.48, 6 districts between 0.48 and 0.52 (a commonly used range to define hyper-competitive seats), and 19 districts with an index of greater than 0.52.

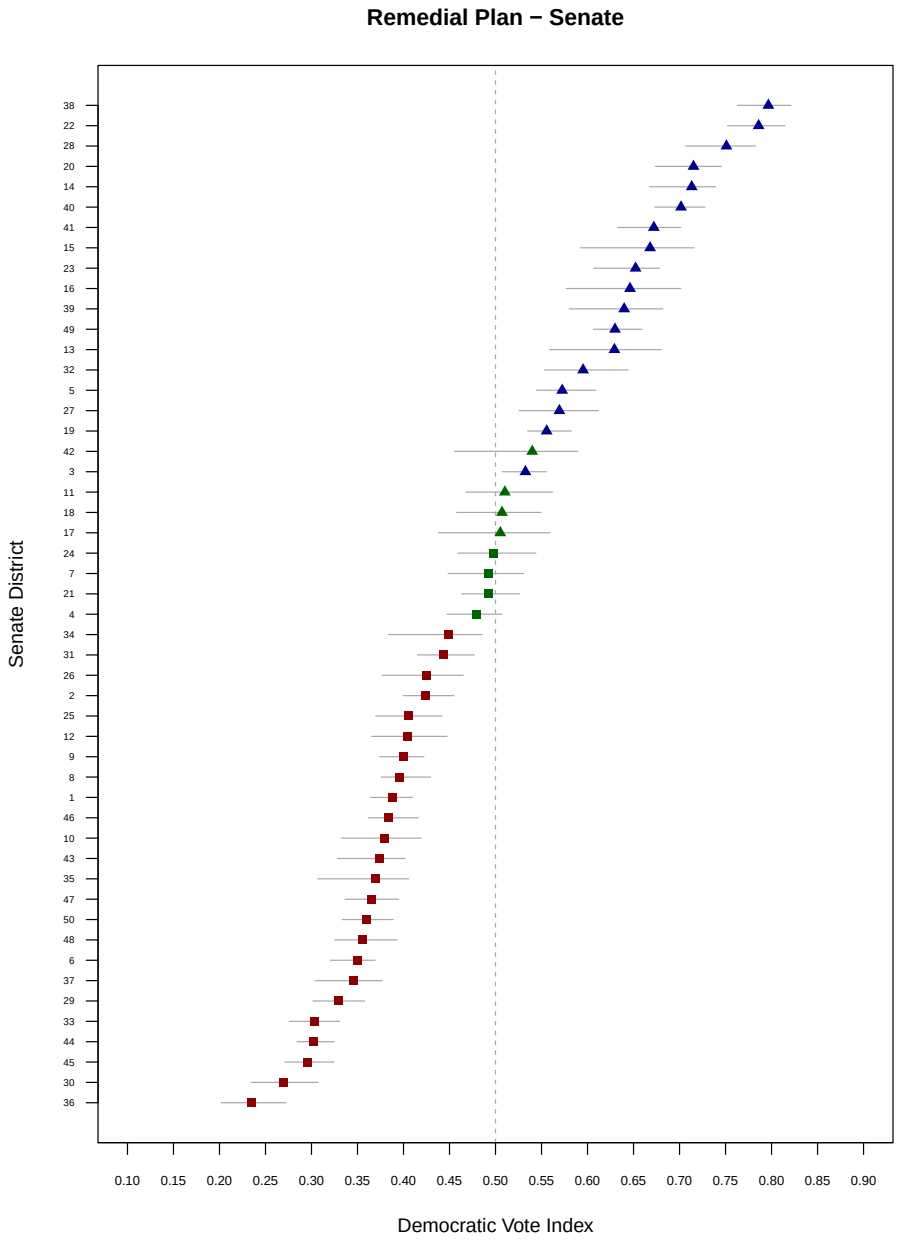


Figure 7: **Partisan Index of Senate Districts in 2022 Remedial plan:** Partisan Index based on the average of 12 statewide partisan races between 2016-2020. Districts with a partisan index less than .50 (i.e. Republican leaning) are shown as squares and districts with a partisan index greater than .50 (i.e. Democratic leaning) are displayed as triangles. A vertical dashed line is placed at .50 in each panel for reference. The grey lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

7.2 Median-Mean Measure

Using the 12 statewide elections described above, the proposed 2022 Remedial Senate map has a median-mean value of -0.65%. This value is within the ±1% standard outlined by the court's ruling. Using the same data and method, the now-enjoined 2021 Enacted Senate plan had a median-mean measure of -3.49%.

7.3 Efficiency Gap Measure

Using the 12 statewide elections described above, the proposed 2022 Remedial Senate plan has an efficiency gap value of -3.97%. This value is within the ±7% standard outlined by the court's ruling. Using the same data and method, the now enjoined 2021 Enacted Senate plan had an efficiency gap value of -8.04%.

7.4 Close Votes, Close Seats

Figure 8 shows the close-votes-close-seats analysis for the Senate plan. The left figure shows the results for the 2021 Enacted Senate plan and the right panel shows the results for the 2022 proposed Remedial Senate plan. The horizontal axis of each chart measures the statewide vote share earned by the Democratic candidates for each of the 12 statewide elections discussed above. The vertical axis of each chart measures the proportion of districts where the Democratic candidate won a majority of the votes in that same election. In other words, this chart is measuring the degree to which statewide votes are translated to seats. The "northwest" and "southeast" quadrants, colored in red, indicate outcomes that are anti-majoritarian, or places where a party wins a majority of the votes statewide but those votes are not translated into a majority of the seats.

In each figure there are 12 dots, one for each of the 12 statewide elections. We see that in the 2021 Enacted Senate plan there are 4 points in the lower right panel representing anti-majoritarian outcomes. The 2022 Remedial Senate map is very different. Only 1 of the

12 points (Attorney General 2020) reside in the lower right quadrant where the Democratic candidate for office one a majority of the votes but those votes would not have translated into a majority of the seats. Notably, in this election the Democratic candidate won with only 50.13% of the vote.

All of the remaining 11 elections produce majoritarian outcomes where a majority of votes statewide translate into a majority of the seats for the state Senate (the Governor 2020 race produces a 25/25 tie). These are the dots in the lower left (southwest) and upper right (northeast) quadrants of the figure.

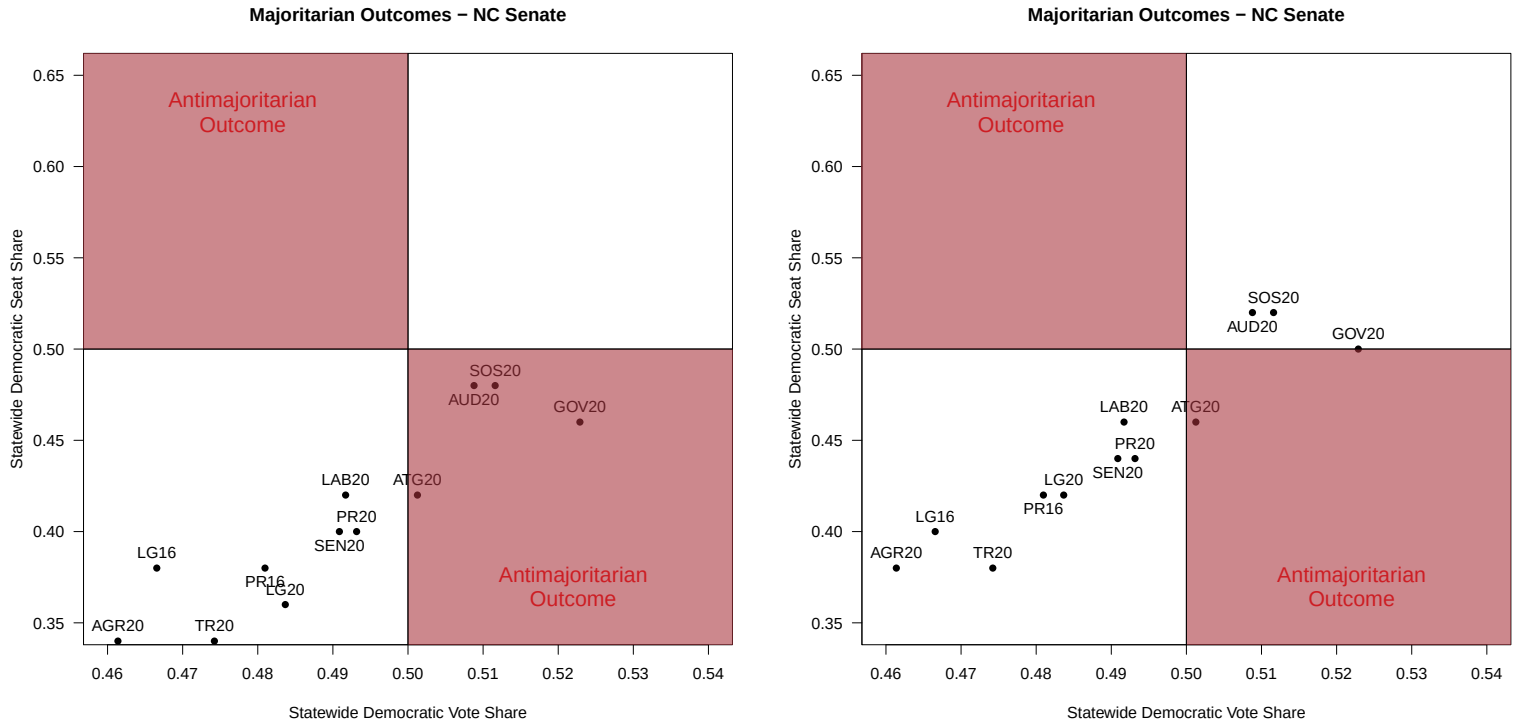
It is not expected that all of the points will fall outside of the red quadrants. As Dr. Duchin states, "It is not practicable to design a map that always attains these properties" (pg. 4, Duchin Report), however, the 2022 Remedial plan performs very well in that 11 of the 12 elections result in majoritarian outcomes.

Furthermore, the points in the 2022 Remedial plan exhibit a general upward slope, meaning that as a party wins more votes statewide their share of the seats based on those votes tends to likewise increase. This indicates a map that is more responsive to changes in voters' preferences.

Figure 8: **Close-Votes-Close-Seats Analysis**

(a) 2021 Enacted Plan

(b) 2022 Remedial plan



Note: Each dot in the figure is a statewide election. The horizontal axis shows the Democratic vote share in each election. The vertical axis shows the proportion of districts that would be won when statewide votes are disaggregated across districts. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

7.5 Partisan Symmetry

Figure 9 shows the seats-votes curve from a uniform partisan swing for the state Senate maps. The left panel shows this for the 2021 Enacted Senate map and the right panel shows this for the 2022 Remedial Senate map. It is immediately apparent that the 2021 Enacted Senate map is less symmetric than the 2022 Remedial Senate map.

Each figure notes two important statistics. The first, seat bias at 50% vote, indicates the distance between 50% of the seats and the predicted seat share when the both parties obtain 50% of the votes. In the 2021 Enacted Senate plan this value is 6%. In other words, in the 2021 Enacted Senate plan when Democrats win 50% of the vote we would predict that they would win 44% of the seats. The 2022 Remedial Senate plan is much improved on this measure. Now when Democrats win 50% of the vote it is predicted that they will win 50% of the seats.

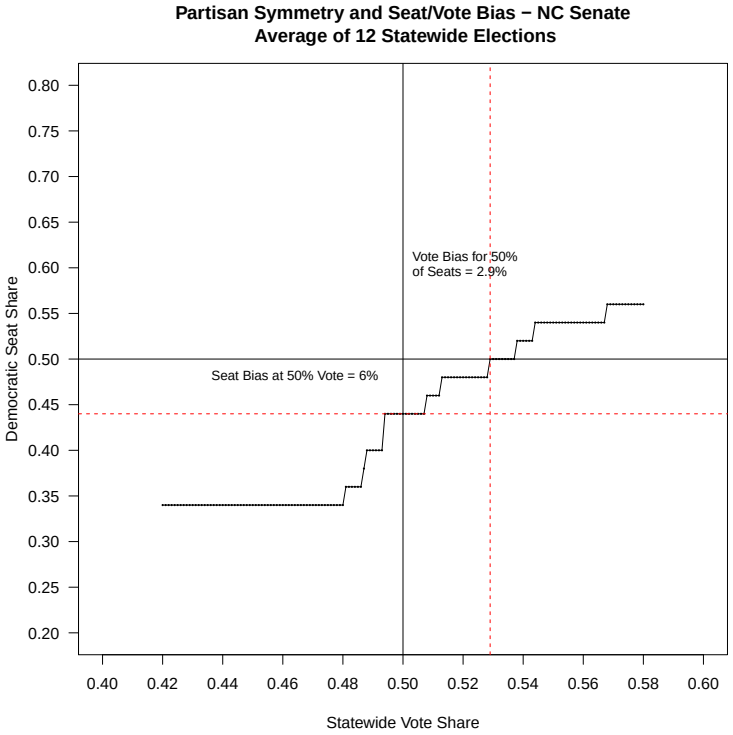
The next statistic to note is the "vote bias for 50% of seats", which measures the proportion of the statewide vote that we would expect a party to need to win in order to obtain 50% of the seats. In the 2021 Enacted Senate plan this is 2.9%. In other words, we would expect Democrats to have to win 52.9% of the statewide vote before they would receive 50% of the seats in the state Senate. This statistic is also much improved in the 2022 Remedial Senate plan. Here the vote bias for 50% of seats is exactly 0%, meaning that we would expect Democrats to win 25 out of the 50 seats in the chamber when they obtain 50% of the statewide vote.

The final thing to note is the overall trajectory of the seats-votes curves in each plot. The 2022 Remedial Senate plan moves in a much smoother and symmetric manner from the bottom left to top right quadrants of the figure. This is not the case in the 2021 Enacted Senate plan. Here the line is much less symmetric in these two quadrants. In the bottom left quadrant the line is relatively flat while in the top right quadrant the line is relatively steep. This would indicate asymmetry in a plan whereas the line in the 2022 Remedial Senate plan is much more symmetric and passes exactly through the 50/50 point at the middle of the

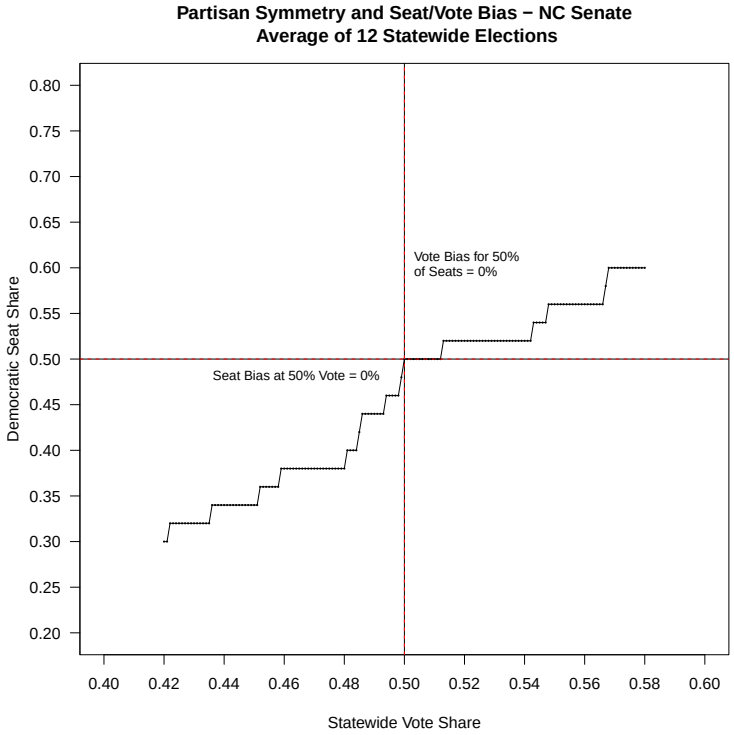
graph.

Figure 9: **Partisan Symmetry Analysis**

(a) 2021 Enacted Plan



(b) 2022 Remedial plan



Note: The horizontal axis measures the statewide vote share from a uniform swing. The vertical axis shows the expected Democratic share of seats. The seats-votes curve shows the relationship between statewide vote shares and expected statewide seat shares. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

7.6 Considerations of Race

During the trail court hearing various plaintiffs discussed the racial composition of Senate districts, the presence or absence of racially polarized voting, and the thresholds necessary for Black voters to elect the candidates of their choice. Table 2 shows the Black voting age population percent for districts with Black incumbents for the districts used in the 2018 election cycle, the 2020 election cycle, the 2021 now-enjoined Enacted Senate districts, and the 2022 Remedial Senate plan.

8 Conclusion for North Carolina Senate Plan

Overall, the 2022 Remedial plan for North Carolina's Senate districts is an improvement over the 2021 Enacted plan on the four measures outlined by the Court. The 2022 Remedial plan is within the Court's thresholds on the median-mean (-0.65%) and efficiency gap (-3.97%) measures. The plan produces majoritarian outcomes in 11 of the 12 elections considered in the close-votes-close-seats analysis and the plan is responsive and symmetric using the seats-votes curve to measure partisan symmetry.

Table 2: BVAP for House Districts with Black Incumbents

Incumbent	2018 District	2018 District %BVAP	Incumbent	2020 District	2020 District %BVAP	SL-2021-173 District	SL-2021-173 District %BVAP	2022 Remedial District	2022 Remedial District %BVAP
Smith, E.	3	44.36%	Bazemore	3	43.04%	1	29.49%	3	42.33%
Fitch	4	47.46%	Fitch	4	47.44%	4	35.02%	4	35.02%
Davis	5	32.94%	Davis	5	35.89%	5	40.35%	5	40.35%
Blue	14	38.85%	Blue	14	33.45%	14	43.25%	14	42.99%
			Batch	17	9.49%	17	10.86%	17	11.47%
Murdock	20	40.35%	Murdock	20	36.79%	20	27.34%	20	27.34%
Clark	21	42.15%	Clark	21	44.13%	24	29.63%	24	29.63%
						19	48.07%	19	39.24%
Foushee	23	12.81%	Foushee	23	11.74%	23	16.73%	23	16.73%
Robinson	28	43.64%	Robinson	28	45.64%	28	51.45%*	28	45.64%
Lewis	32	39.18%	Lowe	32	25.00%	32	35.30%	32	25.19%
			Salvador	39	22.64%	39	40.75%	39	23.13%
Wadell	40	38.88%	Waddell	40	40.59%	40	49.54%	40	38.67%

Note: BVAP percents are "% any part Black." *This district's composition was the result of an amendment offered by that district's incumbent, Democratic Senator Robinson, who stated she thought the district, as amended, was fair and complied with the VRA. The trail court wrote of this: "109. Ultimately, two amendments were accepted in the Senate Committee: (1) An amendment offered by Senator Clark changing the Guilford/Rockingham County grouping (SD26, SD27, and SD28). Senator Hise testified that this amendment was presented at the behest of Senator Robinson, a Democratic member from Guilford, who, under the version presented by the chairs, was double-bunked with Senator Garrett. Trial Tr. 01/05/2022. During debate, Senator Robinson attested in Committee that she understood the amendment complied with the VRA and considered it a fair draw."

I declare under penalty of perjury under the laws of the state of North Carolina that the foregoing is true and correct to the best of my knowledge.

Michael Barber

18 February 2022

Appendix A: Curriculum Vitae

Michael Jay Barber

CONTACT INFORMATION

Brigham Young University
Department of Political Science
724 KMBL
Provo, UT 84602

barber@byu.edu
http://michaeljaybarber.com
Ph: (801) 422-7492

ACADEMIC APPOINTMENTS

Brigham Young University, Provo, UT

August 2020 - present Associate Professor, Department of Political Science
2014 - July 2020 Assistant Professor, Department of Political Science
2014 - present Faculty Scholar, Center for the Study of Elections and Democracy

EDUCATION

Princeton University Department of Politics, Princeton, NJ

Ph.D., Politics, July 2014

- Advisors: Brandice Canes-Wrone, Nolan McCarty, and Kosuke Imai
- Dissertation: "Buying Representation: the Incentives, Ideology, and Influence of Campaign Contributions on American Politics"
- 2015 Carl Albert Award for Best Dissertation, Legislative Studies Section, American Political Science Association (APSA)

M.A., Politics, December 2011

Brigham Young University, Provo, UT

B.A., International Relations - Political Economy Focus, April, 2008

- *Cum Laude*

RESEARCH INTERESTS

American politics, congressional polarization, political ideology, campaign finance, survey research

PUBLICATIONS

19. **"Ideological Disagreement and Pre-emption in Municipal Policymaking"**
with Adam Dynes
Forthcoming at *American Journal of Political Science*
18. **"Comparing Campaign Finance and Vote Based Measures of Ideology"**
Forthcoming at *Journal of Politics*
17. **"The Participatory and Partisan Impacts of Mandatory Vote-by-Mail"**, with John Holbein
Science Advances, 2020. Vol. 6, no. 35, DOI: 10.1126/sciadv.abc7685
16. **"Issue Politicization and Interest Group Campaign Contribution Strategies"**, with Mandi Eatough
Journal of Politics, 2020. Vol. 82: No. 3, pp. 1008-1025

15. **"Campaign Contributions and Donors' Policy Agreement with Presidential Candidates"**, with Brandice Canes-Wrone and Sharece Thrower
Presidential Studies Quarterly, 2019, 49 (4) 770–797

14. **"Conservatism in the Era of Trump"**, with Jeremy Pope
Perspectives on Politics, 2019, 17 (3) 719–736

13. **"Legislative Constraints on Executive Unilateralism in Separation of Powers Systems"**, with Alex Bolton and Sharece Thrower
Legislative Studies Quarterly, 2019, 44 (3) 515–548
Awarded the Jewell-Loewenberg Award for best article in the area of subnational politics published in *Legislative Studies Quarterly* in 2019

12. **"Electoral Competitiveness and Legislative Productivity"**, with Soren Schmidt
American Politics Research, 2019, 47 (4) 683–708

11. **"Does Party Trump Ideology? Disentangling Party and Ideology in America"**, with Jeremy Pope
American Political Science Review, 2019, 113 (1) 38–54

10. **"The Evolution of National Constitutions"**, with Scott Abramson
Quarterly Journal of Political Science, 2019, 14 (1) 89–114

9. **"Who is Ideological? Measuring Ideological Responses to Policy Questions in the American Public"**, with Jeremy Pope
The Forum: A Journal of Applied Research in Contemporary Politics, 2018, 16 (1) 97–122

8. **"Status Quo Bias in Ballot Wording"**, with David Gordon, Ryan Hill, and Joe Price
The Journal of Experimental Political Science, 2017, 4 (2) 151–160.

7. **"Ideologically Sophisticated Donors: Which Candidates Do Individual Contributors Finance?"**, with Brandice Canes-Wrone and Sharece Thrower
American Journal of Political Science, 2017, 61 (2) 271–288.

6. **"Gender Inequalities in Campaign Finance: A Regression Discontinuity Design"**, with Daniel Butler and Jessica Preece
Quarterly Journal of Political Science, 2016, Vol. 11, No. 2: 219–248.

5. **"Representing the Preferences of Donors, Partisans, and Voters in the U.S. Senate"**
Public Opinion Quarterly, 2016, 80: 225–249.

4. **"Donation Motivations: Testing Theories of Access and Ideology"**
Political Research Quarterly, 2016, 69 (1) 148–160.

3. **"Ideological Donors, Contribution Limits, and the Polarization of State Legislatures"**
Journal of Politics, 2016, 78 (1) 296–310.

2. **"Online Polls and Registration Based Sampling: A New Method for Pre-Election Polling"** with Quin Monson, Kelly Patterson and Chris Mann.
Political Analysis 2014, 22 (3) 321–335.

1. **"Causes and Consequences of Political Polarization"** In *Negotiating Agreement in Politics*. Jane Mansbridge and Cathie Jo Martin, eds., Washington, DC: American Political Science Association: 19–53. with Nolan McCarty. 2013.

   - Reprinted in *Solutions to Political Polarization in America*, Cambridge University Press. Nate Persily, eds. 2015
   - Reprinted in *Political Negotiation: A Handbook*, Brookings Institution Press. Jane Mansbridge and Cathie Jo Martin, eds. 2015

Available Working Papers

"Misclassification and Bias in Predictions of Individual Ethnicity from Administrative Records" (Revise and Resubmit at *American Political Science Review*)

"Taking Cues When You Don't Care: Issue Importance and Partisan Cue Taking"
with Jeremy Pope (Revise and Resubmit)

"A Revolution of Rights in American Founding Documents"
with Scott Abramson and Jeremy Pope (Conditionally Accepted)

"410 Million Voting Records Show the Distribution of Turnout in America Today"
with John Holbein (Revise and Resubmit)

"Partisanship and Trolleyology"
with Ryan Davis (Under Review)

"Who's the Partisan: Are Issues or Groups More Important to Partisanship?"
with Jeremy Pope (Revise and Resubmit)

"Race and Realignment in American Politics"
with Jeremy Pope (Revise and Resubmit)

"The Policy Preferences of Donors and Voters"

"Estimating Neighborhood Effects on Turnout from Geocoded Voter Registration Records."
with Kosuke Imai

"Super PAC Contributions in Congressional Elections"

Works in Progress

"Collaborative Study of Democracy and Politics"
with Brandice Canes-Wrone, Gregory Huber, and Joshua Clinton

"Preferences for Representational Styles in the American Public"
with Ryan Davis and Adam Dynes

"Representation and Issue Congruence in Congress"
with Taylor Petersen

"Education, Income, and the Vote for Trump"
with Edie Ellison

Invited Presentations

"Are Mormons Breaking Up with Republicanism? The Unique Political Behavior of Mormons in the 2016 Presidential Election"

- Ivy League LDS Student Association Conference - Princeton University, November 2018, Princeton, NJ

"Issue Politicization and Access-Oriented Giving: A Theory of PAC Contribution Behavior"

- Vanderbilt University, May 2017, Nashville, TN

"Lost in Issue Space? Measuring Levels of Ideology in the American Public"

- Yale University, April 2016, New Haven, CT

"The Incentives, Ideology, and Influence of Campaign Donors in American Politics"

- University of Oklahoma, April 2016, Norman, OK

"Lost in Issue Space? Measuring Levels of Ideology in the American Public"

- University of Wisconsin - Madison, February 2016, Madison, WI

"Polarization and Campaign Contributors: Motivations, Ideology, and Policy"

- Hewlett Foundation Conference on Lobbying and Campaign Finance, October 2014, Palo Alto, CA

"Ideological Donors, Contribution Limits, and the Polarization of State Legislatures"

- Bipartisan Policy Center Meeting on Party Polarization and Campaign Finance, September 2014, Washington, DC

"Representing the Preferences of Donors, Partisans, and Voters in the U.S. Senate"

- Yale Center for the Study of American Politics Conference, May 2014, New Haven, CT

Conference Presentations

Washington D.C. Political Economy Conference (PECO):

- 2017 discussant

American Political Science Association (APSA) Annual Meeting:

- 2014 participant and discussant, 2015 participant, 2016 participant, 2017 participant, 2018 participant

Midwest Political Science Association (MPSA) Annual Meeting:

- 2015 participant and discussant, 2016 participant and discussant, 2018 participant

Southern Political Science Association (SPSA) Annual Meeting:

- 2015 participant and discussant, 2016 participant and discussant, 2017 participant

Teaching Experience

Poli 315: Congress and the Legislative Process

- Fall 2014, Winter 2015, Fall 2015, Winter 2016, Summer 2017

Poli 328: Quantitative Analysis

- Winter 2017, Fall 2017, Fall 2019, Winter 2020, Fall 2020, Winter 2021

Poli 410: Undergraduate Research Seminar in American Politics

- Fall 2014, Winter 2015, Fall 2015, Winter 2016, Summer 2017

Awards and Grants

2019 BYU Mentored Environment Grant (MEG), American Ideology Project, $30,000

2017 BYU Political Science Teacher of the Year Award

2017 BYU Mentored Environment Grant (MEG), Funding American Democracy Project, $20,000

2016 BYU Political Science Department, Political Ideology and President Trump (with Jeremy Pope), $7,500

2016 BYU Office of Research and Creative Activities (ORCA) Student Mentored Grant x 3

- Hayden Galloway, Jennica Peterson, Rebecca Shuel

2015 BYU Office of Research and Creative Activities (ORCA) Student Mentored Grant x 3

- Michael-Sean Covey, Hayden Galloway, Sean Stephenson

2015 BYU Student Experiential Learning Grant, American Founding Comparative Constitutions Project (with Jeremy Pope), $9,000

2015 BYU Social Science College Research Grant, $5,000

2014 BYU Political Science Department, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), $3,000

2014 BYU Social Science College Award, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), $3,000

2014 BYU Center for the Study of Elections and Democracy, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), $2,000

2012 Princeton Center for the Study of Democratic Politics Dissertation Improvement Grant, $5,000

2011 Princeton Mamdouha S. Bobst Center for Peace and Justice Dissertation Research Grant, $5,000

2011 Princeton Political Economy Research Grant, $1,500

Other Scholarly Activities

Expert Witness in Nancy Carola Jacobson, et al., Plaintiffs, vs. Laurel M. Lee, et al., Defendants. Case No. 4:18-cv-00262 MW-CAS (U.S. District Court for the Northern District of Florida)

Expert Witness in Common Cause, et al., Plaintiffs, vs. LEWIS, et al., Defendants. Case No. 18-CVS-14001 (Wake County, North Carolina)

Expert Witness in Kelvin Jones, et al., Plaintiffs, v. Ron DeSantis, et al., Defendants, Consolidated Case No. 4:19-cv-300 (U.S. District Court for the Northern District of Florida)

Expert Witness in Community Success Initiative, et al., Plaintiffs, v. Timothy K. Moore, et al., Defendants, Case No. 19-cv-15941 (Wake County, North Carolina)

Expert Witness in Richard Rose et al., Plaintiffs, v. Brad Raffensperger, Defendant, Civil Action No. 1:20-cv-02921-SDG (U.S. District Court for the Northern District of Georgia)

Georgia Coalition for the People's Agenda, Inc., et. al., Plaintiffs, v. Brad Raffensberger, Defendant. Civil Action No. 1:18-cv-04727-ELR (U.S. District Court for the Northern District of Georgia)

Expert Witness in Alabama, et al., Plaintiffs, v. United States Department of Commerce; Gina Raimondo, et al., Defendants. Case No. CASE No. 3:21-cv-00211-RAH-ECM-KCN (U.S. District Court for the Middle District of Alabama Eastern Division)

Expert Witness in League of Women Voters of Ohio, et al., Relators, v. Ohio Redistricting Commission, et al., Respondents. Case No. 2021-1193 (Supreme Court of Ohio)

Additional Training	EITM 2012 at Princeton University - Participant and Graduate Student Coordinator
Computer Skills	Statistical Programs: R, Stata, SPSS, parallel computing

Updated December 22, 2021

No. 413PA21 TENTH DISTRICT

SUPREME COURT OF NORTH CAROLINA

STATE OF NORTH CAROLINA

COUNTY OF WAKE

REBECCA HARPER, *et al.*,

Plaintiffs,

v.

REPRESENTATIVE DESTIN HALL, in his official capacity as Chair of the House Standing Committee on Redistricting, *et al.*,

Defendants.

IN THE GENERAL COURT OF JUSTICE
SUPERIOR COURT DIVISION
No. 21 CVS 500085

HARPER PLAINTIFFS' NOTICE OF APPEAL

STATE OF NORTH CAROLINA

COUNTY OF WAKE

NORTH CAROLINA LEAGUE OF CONSERVATION VOTERS, INC., *et al.*,

Plaintiffs,

and

COMMON CAUSE,

Plaintiff-Intervenor,

v.

REPRESENTATIVE DESTIN HALL, in his official capacity as Chair of the House Standing Committee on Redistricting, *et al.*,

Defendants.

IN THE GENERAL COURT OF JUSTICE
SUPERIOR COURT DIVISION
No. 21 CVS 015426

TO THE HONORABLE SUPREME COURT OF NORTH CAROLINA:

Pursuant to the Supreme Court of North Carolina's order issued on February 4, 2022, and Rule 3 of the North Carolina Rules of Appellate Procedure, the *Harper* Plaintiffs hereby give notice of appeal to the Supreme Court of North Carolina from the February 23, 2022 Order on Remedial Plans of the Wake County Superior Court to the extent that it adopts the remedial State Senate plan enacted as S.B. 744.

Dated: February 23, 2022 By: 

PATTERSON HARKAVY LLP

Burton Craige, NC Bar No. 9180
Narendra K. Ghosh, NC Bar No. 37649
Paul E. Smith, NC Bar No. 45014
100 Europa Dr., Suite 420
Chapel Hill, NC 27517
(919) 942-5200
bcraige@pathlaw.com
nghosh@pathlaw.com
psmith@pathlaw.com

Counsel for Plaintiffs

ELIAS LAW GROUP LLP

Abha Khanna*
1700 Seventh Avenue, Suite 2100
Seattle, Washington 98101
Phone: (206) 656-0177
Facsimile: (206) 656-0180
AKhanna@elias.law

Lalitha D. Madduri*
Jacob D. Shelly*
Graham W. White*
10 G Street NE, Suite 600
Washington, D.C. 20002
Phone: (202) 968-4490
Facsimile: (202) 968-4498
LMadduri@elias.law
JShelly@elias.law
GWhite@elias.law

ARNOLD AND PORTER KAYE SCHOLER LLP

Elisabeth S. Theodore*
R. Stanton Jones*
Samuel F. Callahan*
601 Massachusetts Avenue NW
Washington, DC 20001-3743
(202) 954-5000
elisabeth.theodore@arnoldporter.com

Counsel for Plaintiffs
* Admitted *pro hac vice*

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a copy of the foregoing *by email*, addressed to the following counsel for the other parties:

Amar Majmundar
Stephanie A. Brennan
Terence Steed
NC Department of Justice
P.O. Box 629
Raleigh, NC 27602
amajmundar@ncdoj.gov
sbrennan@ncdoj.gov
tsteed@ncdoj.gov

Counsel for the State Defendants

Allison J. Riggs
Hilary H. Klein
Mitchell Brown
Katelin Kaiser
Jeffrey Loperfido
Southern Coalition for Social Justice
1415 W. Highway 54, Suite 101
Durham, NC 27707
allison@southerncoalition.org
hilaryhklein@scsj.org
mitchellbrown@scsj.org
katelin@scsj.org
jeffloperfido@scsj.org

J. Tom Boer
Olivia T. Molodanof
Hogan Lovells US LLP
3 Embarcadero Center, Suite 1500
San Francisco, CA 94111
tom.boer@hoganlovells.com
oliviamolodanof@hoganlovells.com

Counsel for Plaintiff Common Cause

Phillip J. Strach
Alyssa Riggins
John E. Branch, III
Thomas A. Farr
Nelson Mullins Riley & Scarborough LLP
4140 Parklake Ave., Suite 200
Raleigh, NC 27612
phil.strach@nelsonmullins.com
alyssa.riggins@nelsonmullins.com
john.branch@nelsonmullins.com
tom.farr@nelsonmullins.com

Mark E. Braden
Katherine McKnight
Baker Hostetler LLP
1050 Connecticut Avenue NW,
Suite 1100
Washington, DC 20036
mbraden@bakerlaw.com
kmcknight@bakerlaw.com

Counsel for the Legislative Defendants

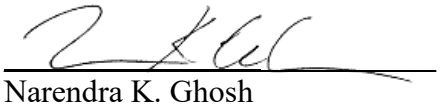
Stephen D. Feldman
Adam K. Doerr
Erik R. Zimmerman
Robinson, Bradshaw & Hinson PA
434 Fayetteville Street, Suite 1600
Raleigh, NC 27601
sfeldman@robinsonbradshaw.com
adoerr@robinsonbradshaw.com
ezimmerman@robinsonbradshaw.com

Sam Hirsch
Jessica Ring Amunson
Zachary C. Schuaf
Karthik P. Reddy
Urja Mittal
JENNER & BLOCK LLP
1099 New York Avenue, NW, Suite 900
Washington, D.C. 20001

shirsch@jenner.com
jamunson@jenner.com
zschauf@jenner.com
kreddy@jenner.com
umittal@jenner.com

Counsel for NCLCV Plaintiffs

This the 23rd day of February, 2022.



Narendra K. Ghosh