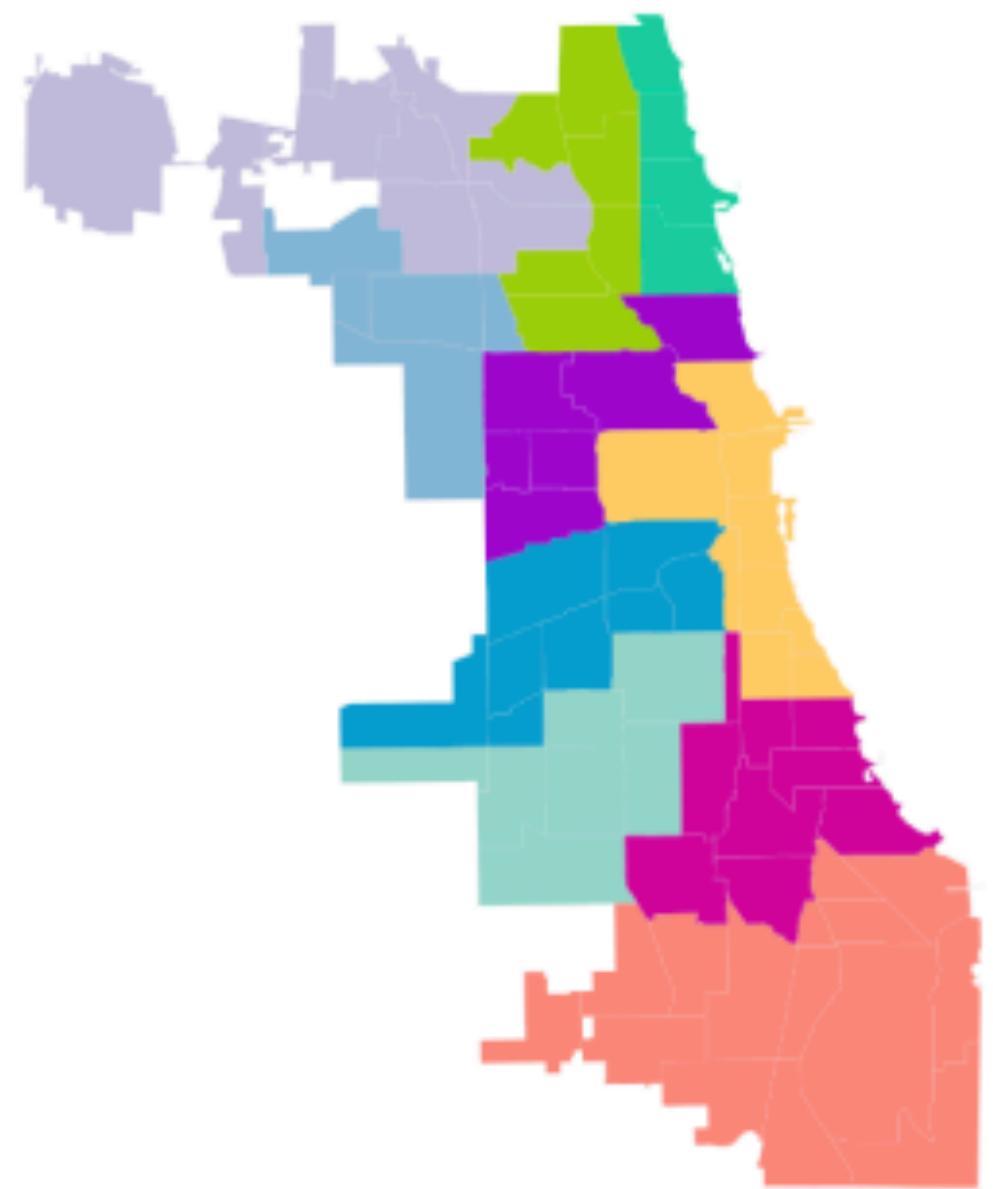
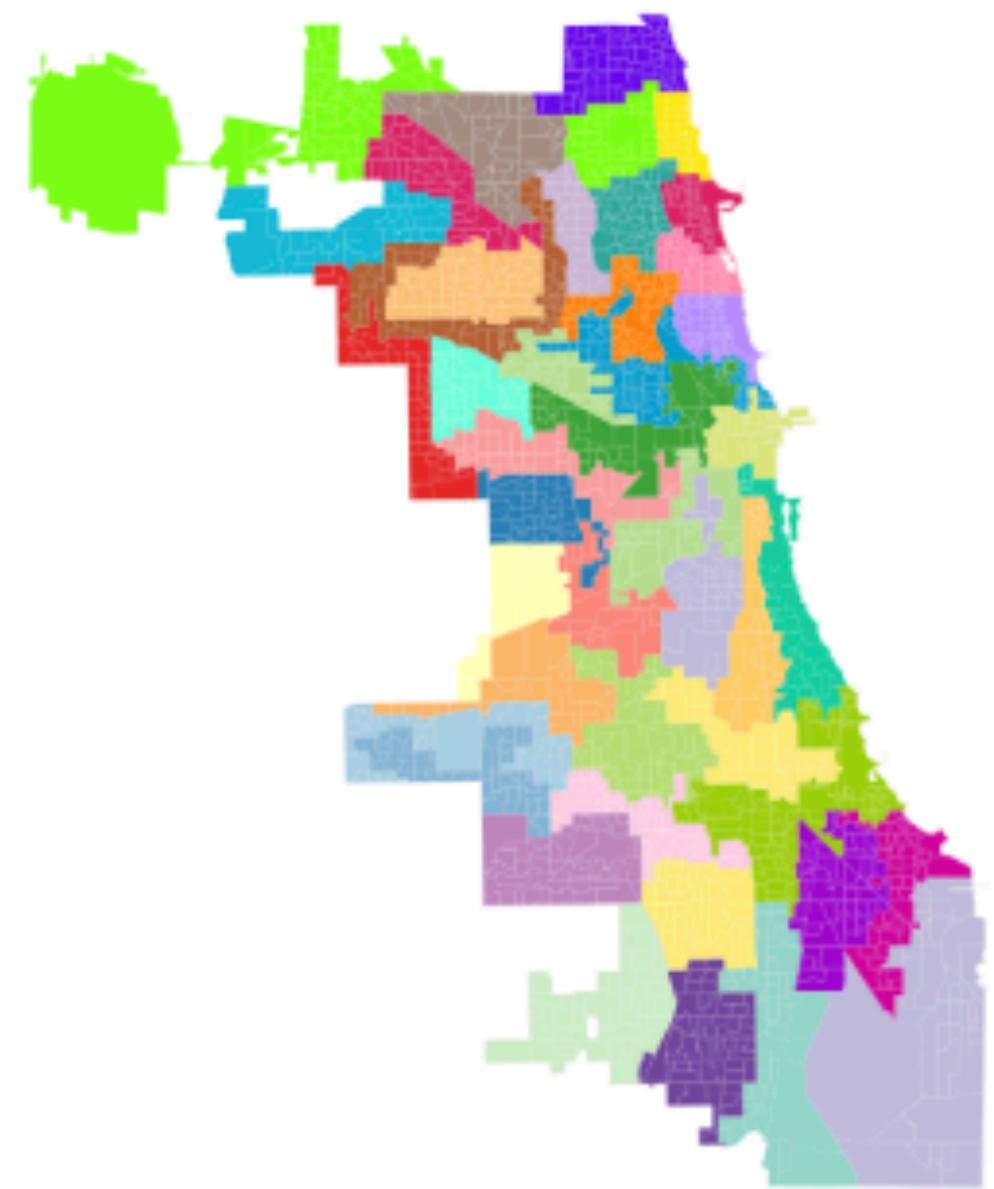


Walk-through of **Chicago** study



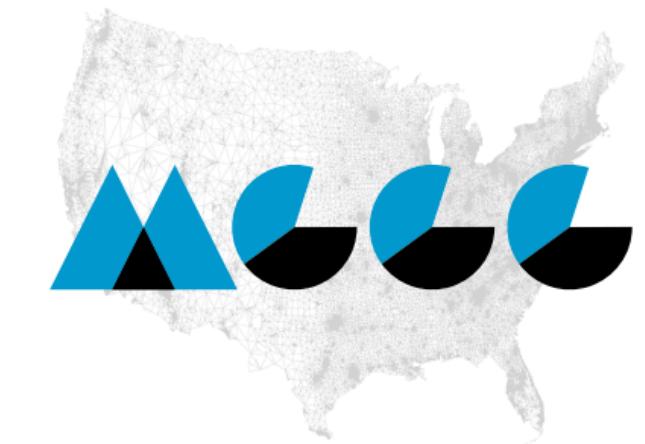
Voting Methods Modeling Workshop
Day 1 – Wednesday June 18, 2025

City council study from 2019

mggg.org/chicago

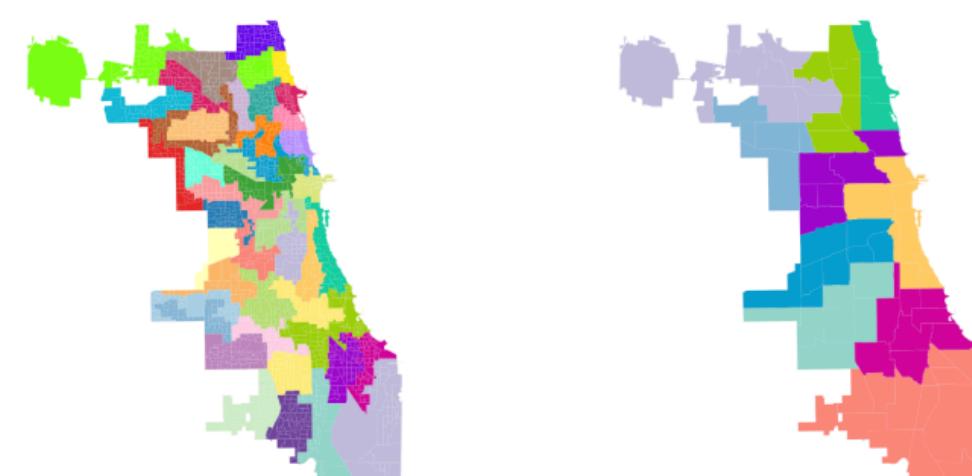
- Goals of study: consider solutions for **gerrymandering**, **hyper-segregation**, **entrenchment**, and **inefficiency**
- What are the options considered?
 - status quo: **50x1**, PSMD, but with new lines (**p**lurality in **s**ingle-**m**ember **d**istricts)
 - **10x5** — ten districts electing 5 members each by ranked choice (STV)
 - **10x3** — shrink the council by drawing ten districts electing 3 each by STV

Study of Reform Proposals
for Chicago City Council



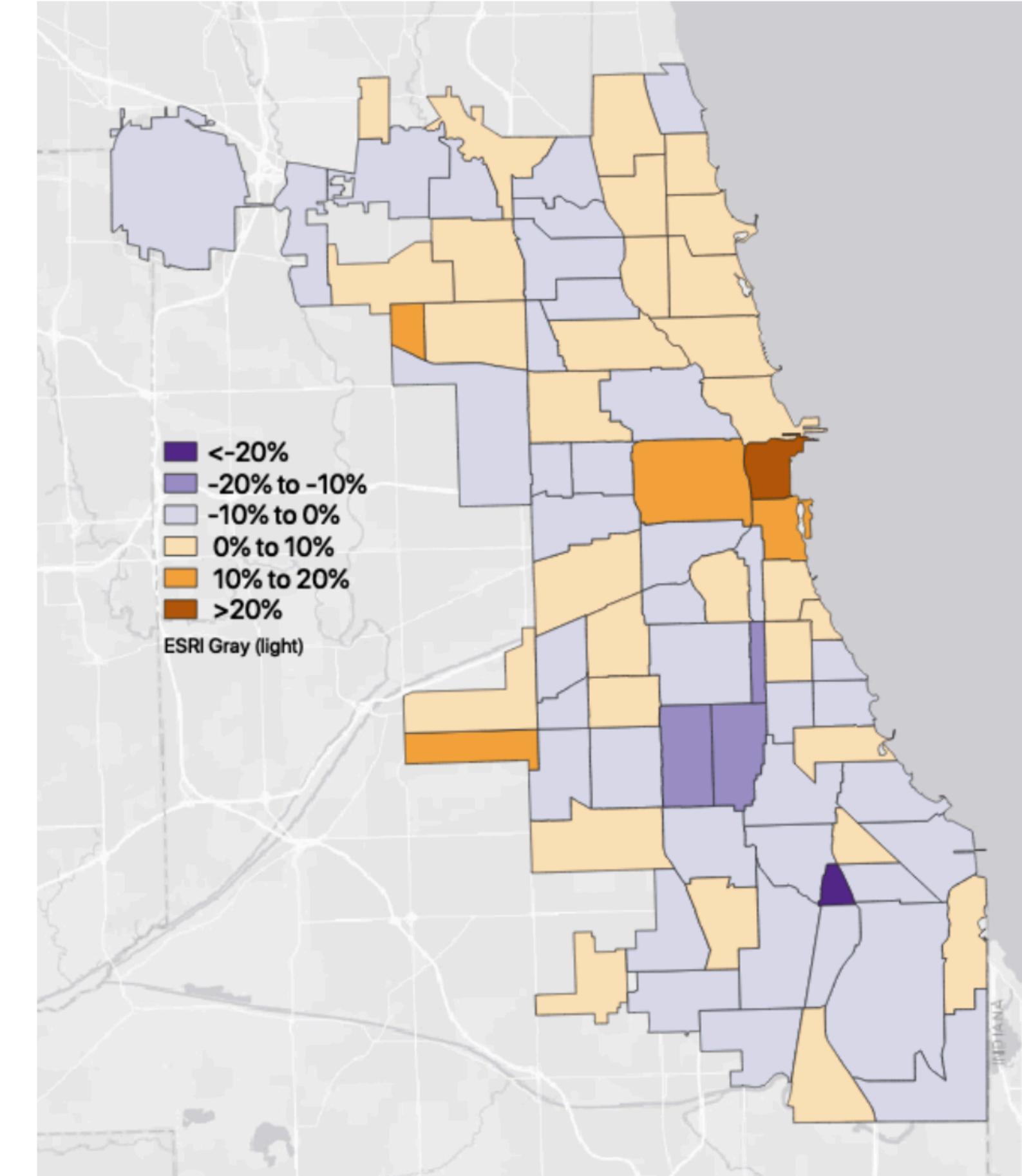
Abstract

Many observers agree that the Chicago City Council ward system suffers from problems of gerrymandering, intense segregation, vestiges of machine politics, and inefficiency. In this report, we apply mathematical models to analyze the current ward plan and compare several reform proposals to address its problems. Our findings strongly support a transition to multi-member wards with ranked choice voting to secure and sustain fair representation.



background on Chicago

77 “Community Areas” (official neighborhoods)



Demographics

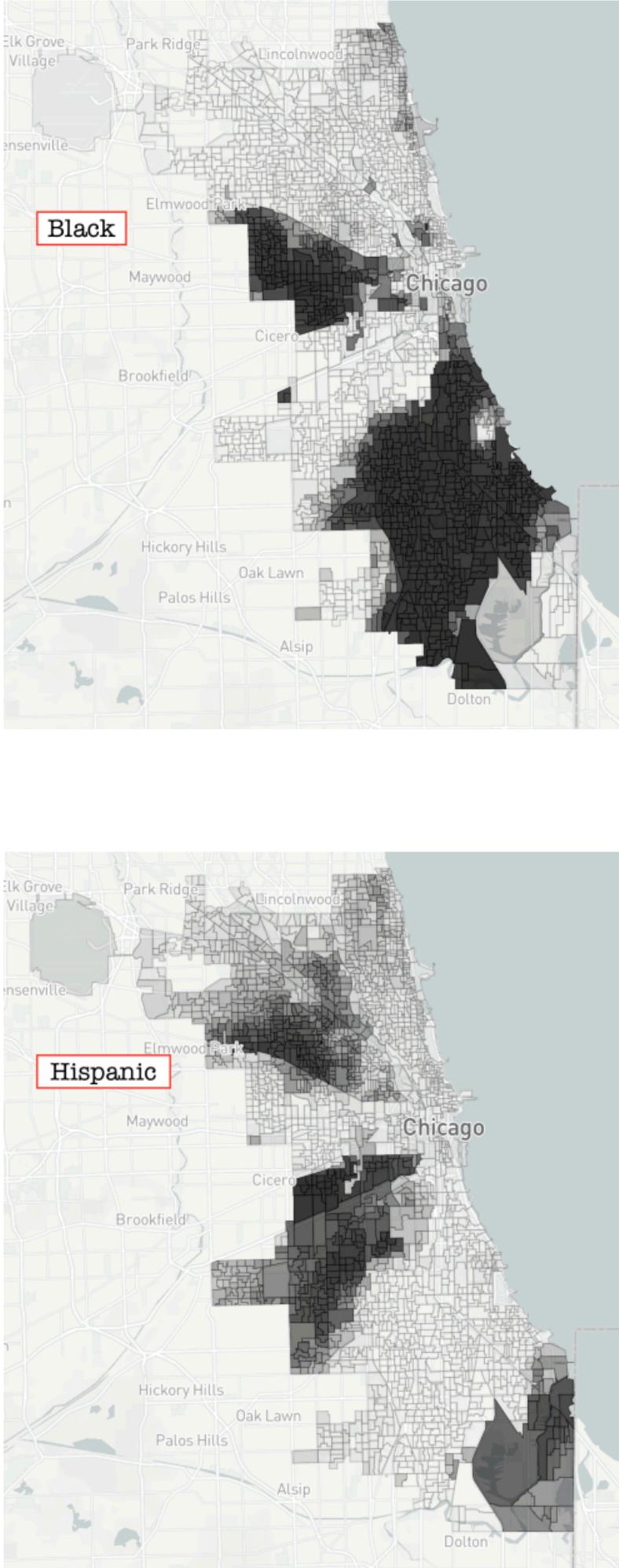


Figure 2. Choropleths of the four largest racial groups in Chicago.

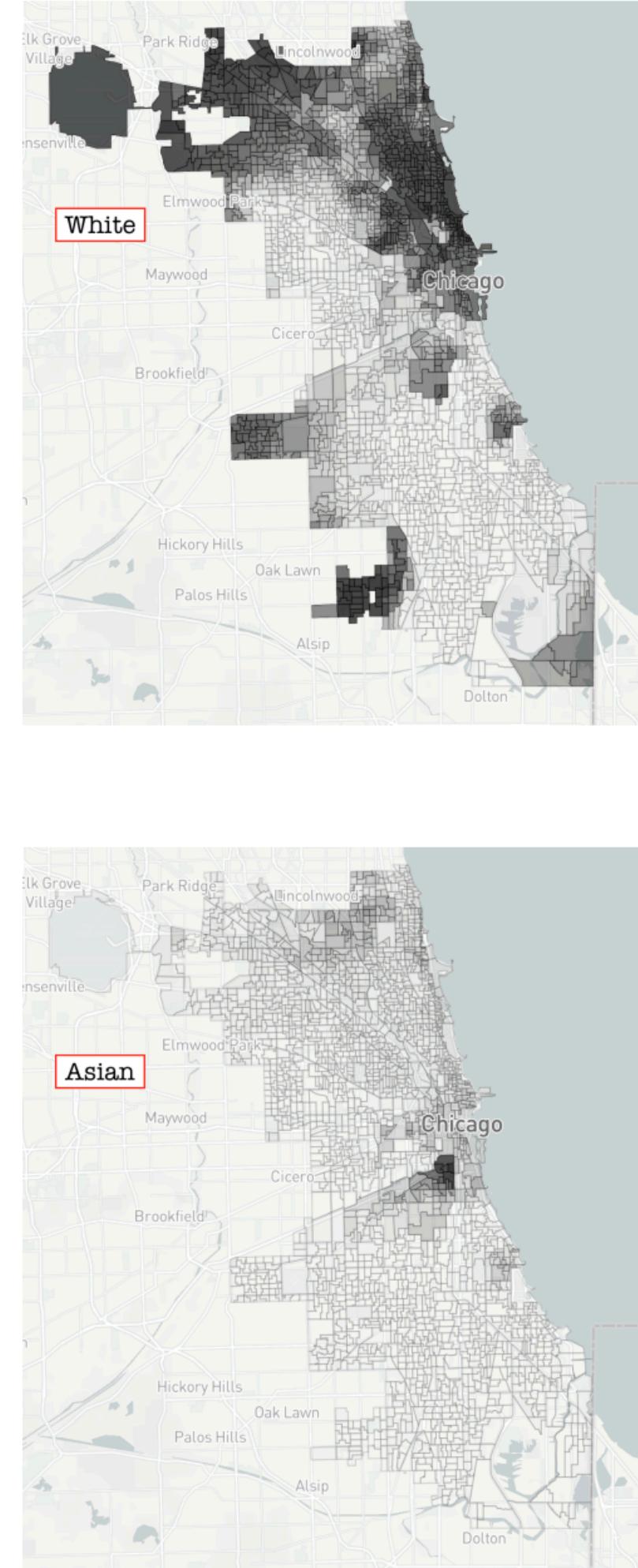
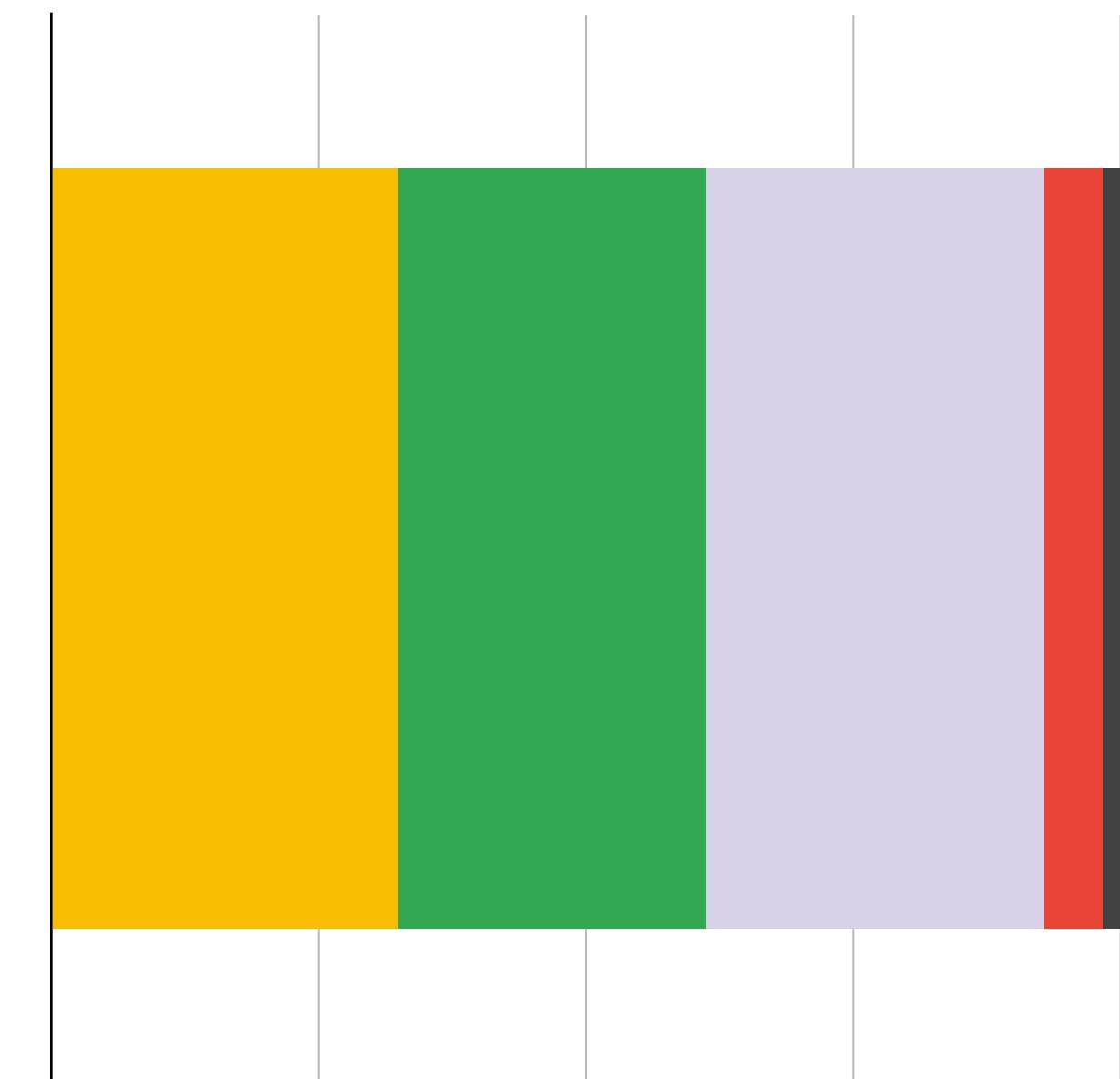


Figure 3. The left-hand figure displays rates of poverty from the 2013–17 ACS, showing the proportion of households in each precinct with less than \$20K in annual income (compared to a citywide level of 21.33%). On the right, rates of affluence, showing the proportion of households with more than \$150K in annual income (citywide 12.8%).

City vs Council demographics

(as of 2015 race)

- 18/18 majority-Black wards elected Black rep
- 10/14 majority-Latino wards elected Latino rep, 3 White & “legacy,”
1 White with strong ties to Latino community
- 13/14 majority-White wards elected White reps, 1 had Asian rep
- 4/4 no-majority wards were plurality White, elected White reps



■ Black ■ Latino ■ White ■ Asian

CITY 2010

ELECTED 2015

Race	2000 (Census)	2010 (Census)	2009-2013 (ACS)	2013-2017 (ACS)
Black (non-Hispanic)	36.4%	32.4%	31.9%	30.1%
White (non-Hispanic)	31.3%	31.7%	32.2%	32.7%
Hispanic	26%	28.9%	28.7%	29%
Asian (non-Hispanic)	4.3%	5.4%	5.7%	6.2%
Two or More Races	1.6%	1.3%	1.3%	1.7%
Amer. Indian/Alaska Native	0.1%	0.2%	0.1%	0.1%
Some Other Race	0.1%	0.2%	0.2%	0.2%
Nat. Hawaiian/Pacific Islander	0.03%	0.02%	0.02%	0.02%
Total Population	2,896,016	2,695,598	2,706,101	2,716,450

demographics of the districts

VS

demographics of the city

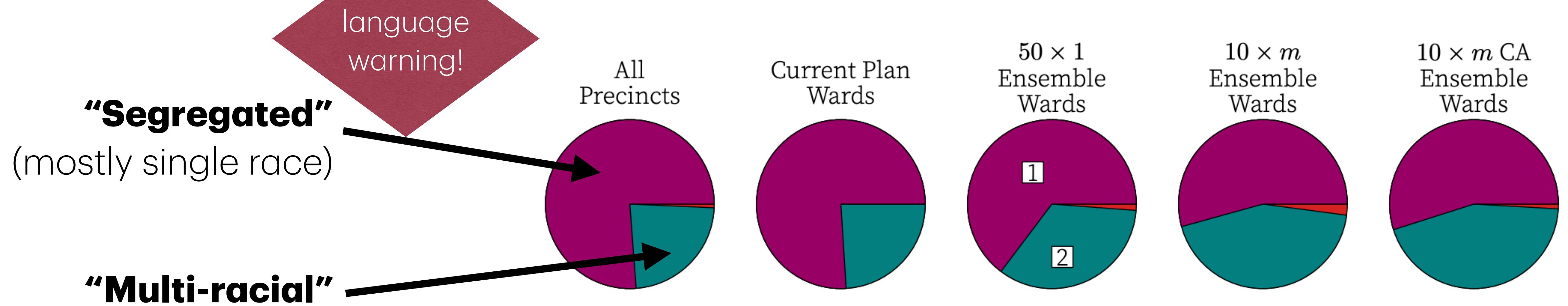


Figure 6. How many racial groups exceed 1/4 of the population? Segregated units (where only one group exceeds that level) are shown here in the purple share of each chart, labeled **1**. (Compare Figure 10, which shows that only 0.1% of alternative plans are as segregated as the current plan.)

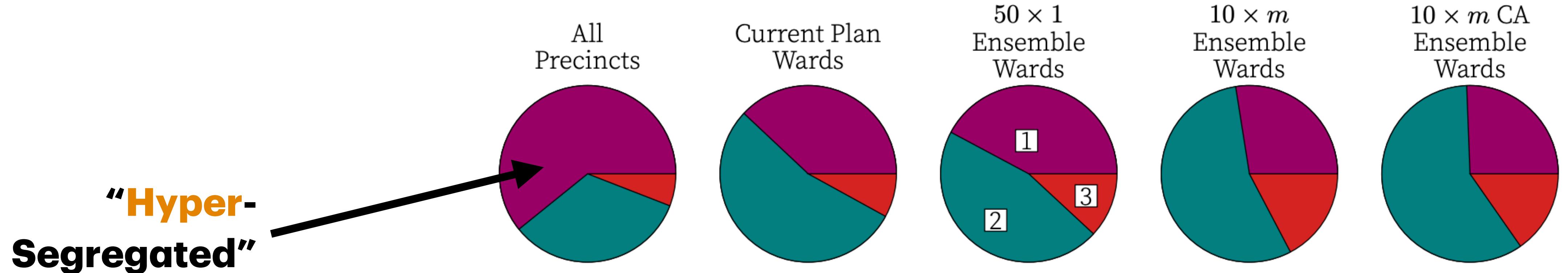


Figure 7. How many racial groups exceed 1/6 of the population? An answer of **1** indicates a hyper-segregated unit. This viewpoint also favors the move to multi-member wards. Also note that 1/6 is the election threshold for districts of magnitude five ($m = 5$) using STV. If ten wards elect five aldermen each, the last two charts show that within-ward diversity will be significantly improved, with a high likelihood of multiracial representation from **2** or **3** groups.

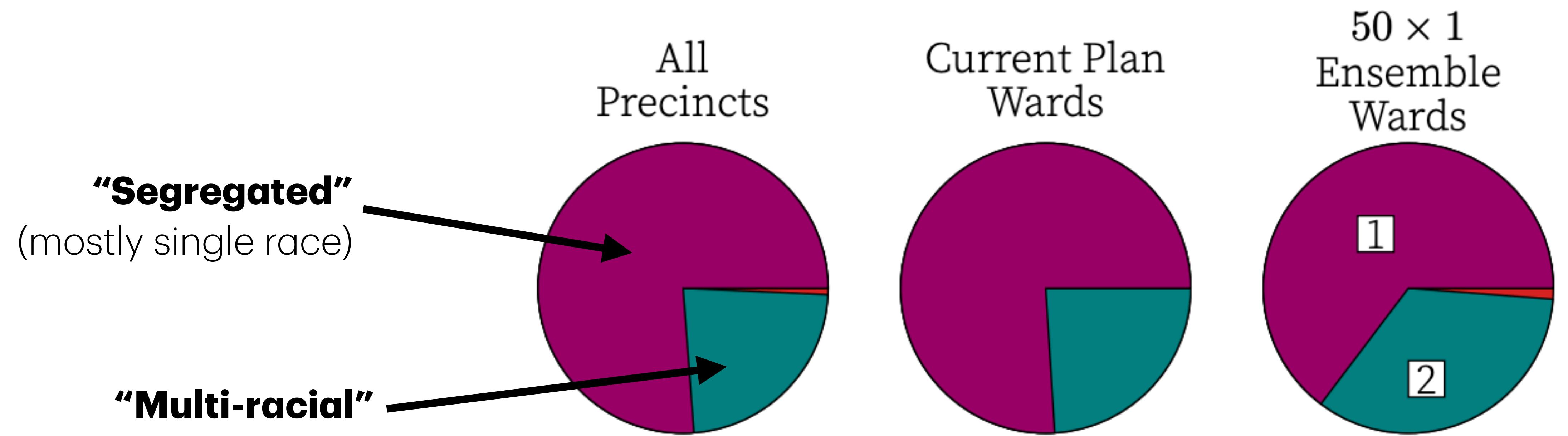


Figure 6. How many racial groups exceed 1/4 of the population (group exceeds that level) are shown here in the purple share. Figure 10, which shows that only 0.1% of alternative plans a

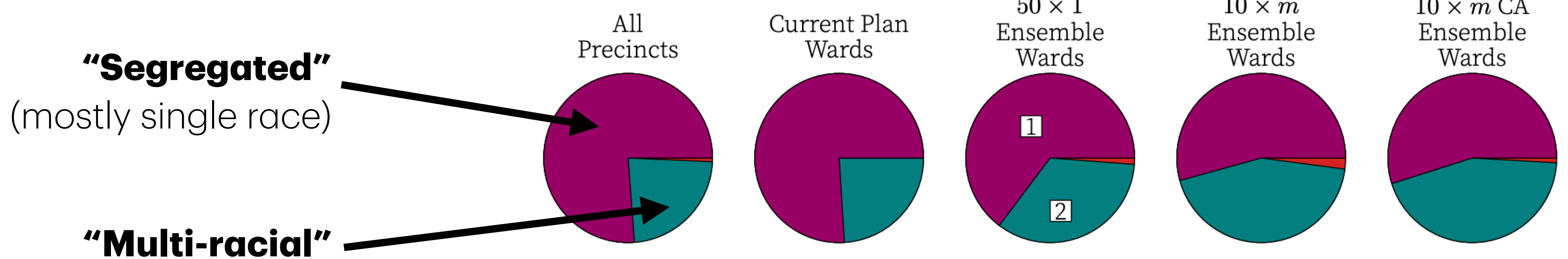


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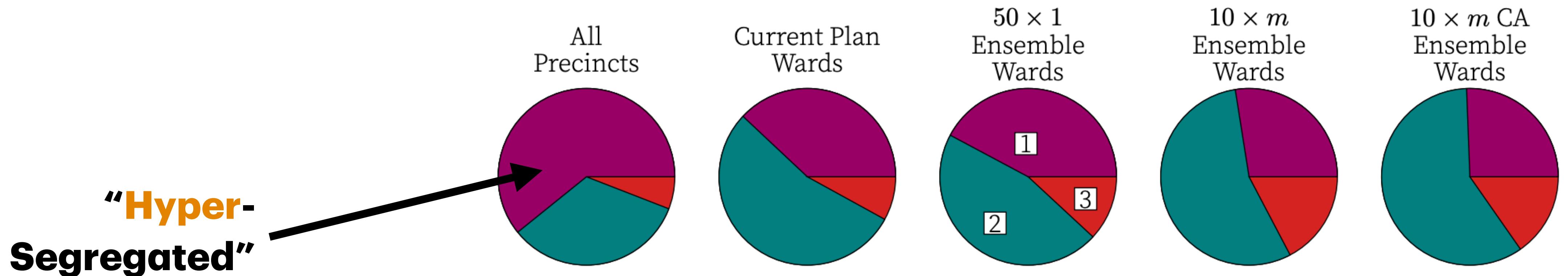


Figure 7. How many racial groups exceed 1/6 of the population? An answer of 1 indicates a hyper-segregated unit. This viewpoint also favors the move to multi-member wards. Also note that 1/6 is the election threshold for districts of magnitude five ($m = 5$) using STV. If ten wards elect five aldermen each, the last two charts show that within-ward diversity will be significantly improved, with a high likelihood of multiracial representation from 2 or 3 groups.

systems of election

“Alternative” systems

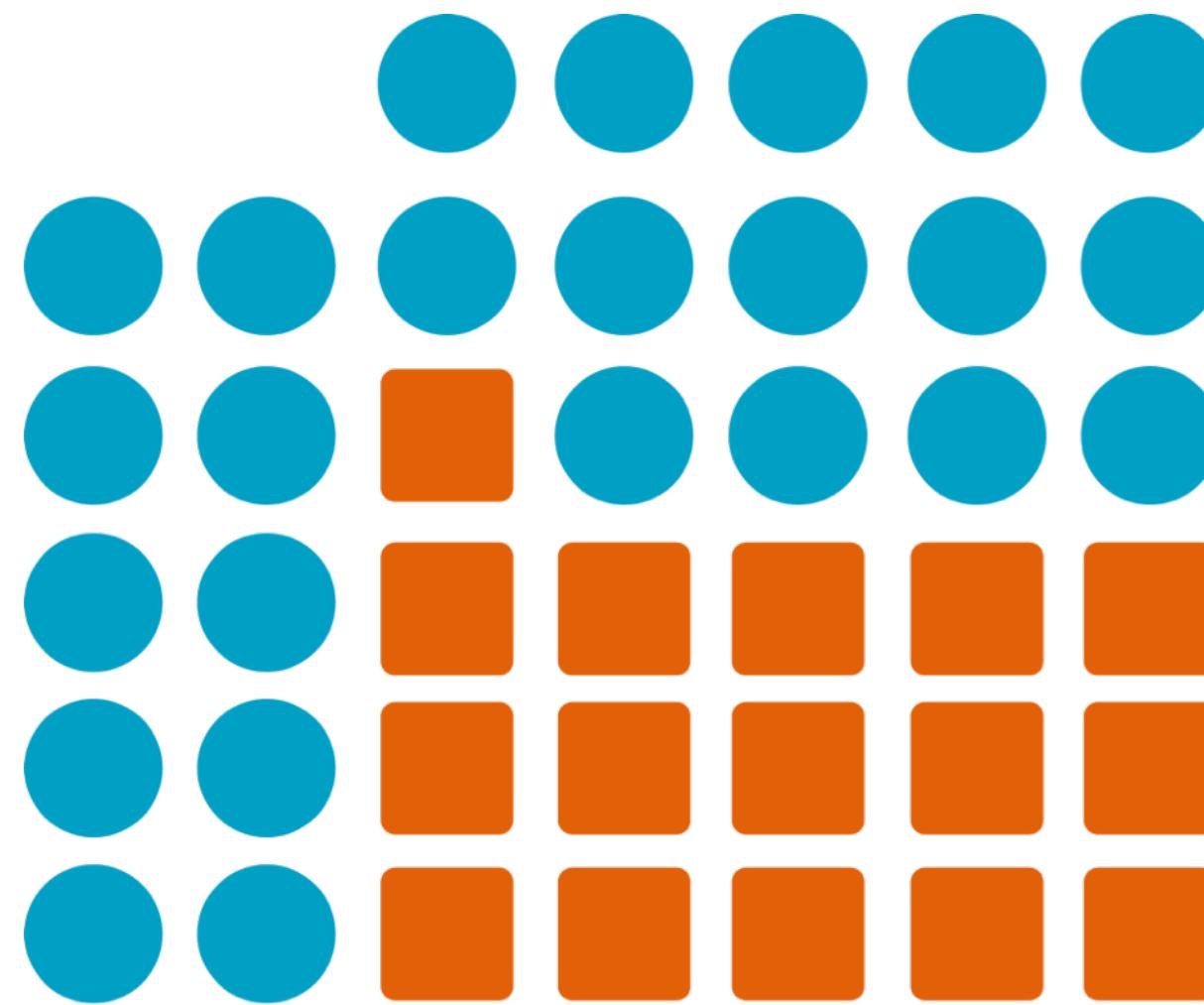
- There are many!
- Besides PSMD, we will focus on “**ranked choice**” (STV and IRV) this week
- But we are **modelers**, not **advocates**, and happy to consider anything
- VoteKit also implements:
 - Borda, Cumulative, Limited, Approval, Smith, Condorcet, PluralityVeto,
 - and lets you make your own!

What are STV and IRV?

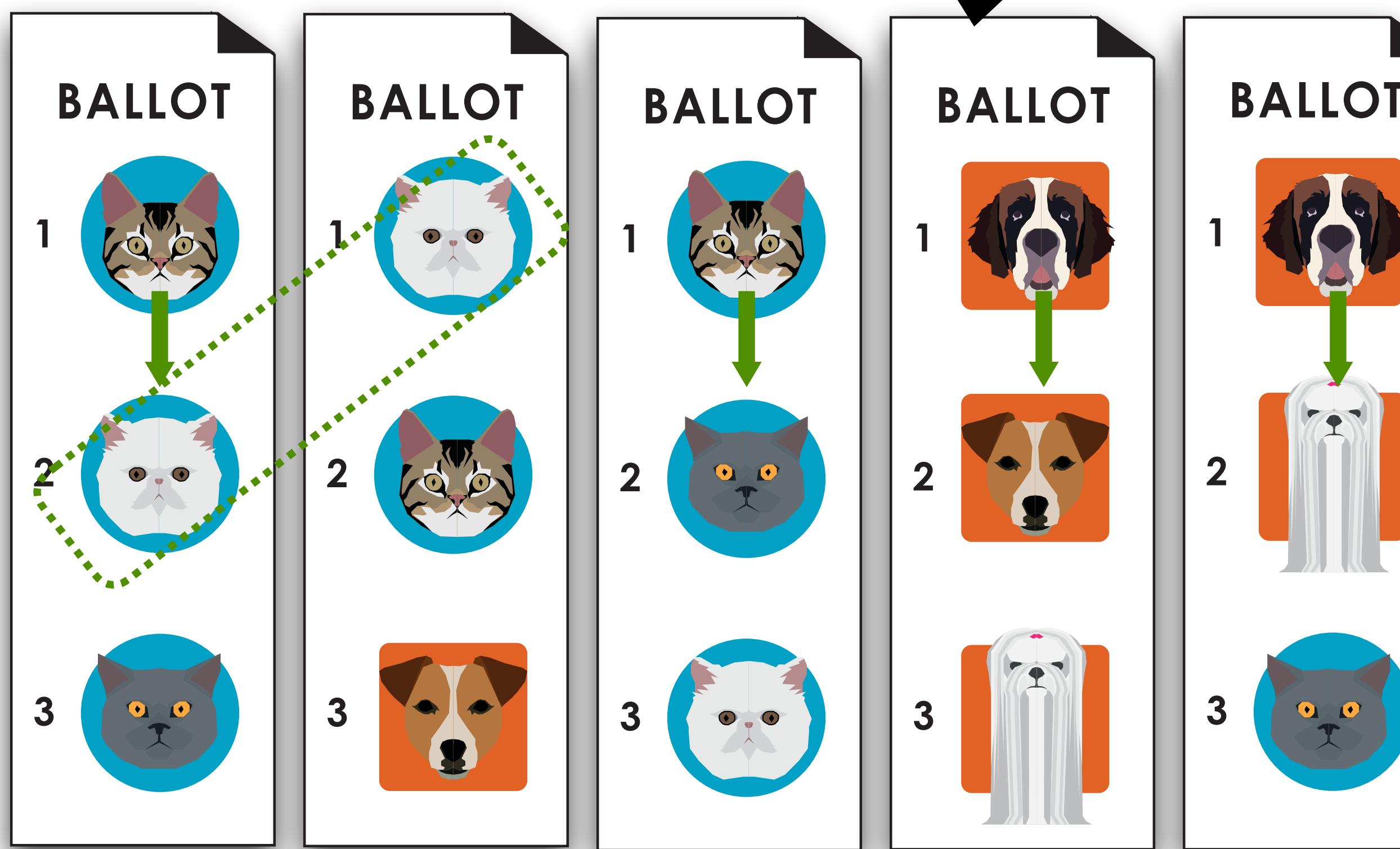
- Voters **rank** choices
- There's a **threshold** of election
- If nobody over threshold, **eliminate** those with least first-place support
- Your support sits with your first-place choice until they are elected or eliminated
- If eliminated, support **transfers** fully
- If elected, **surplus** support transfers (so weight transfers fractionally)

IRV - one winner

STV - multi



**40% dog lovers
60% cat lovers**

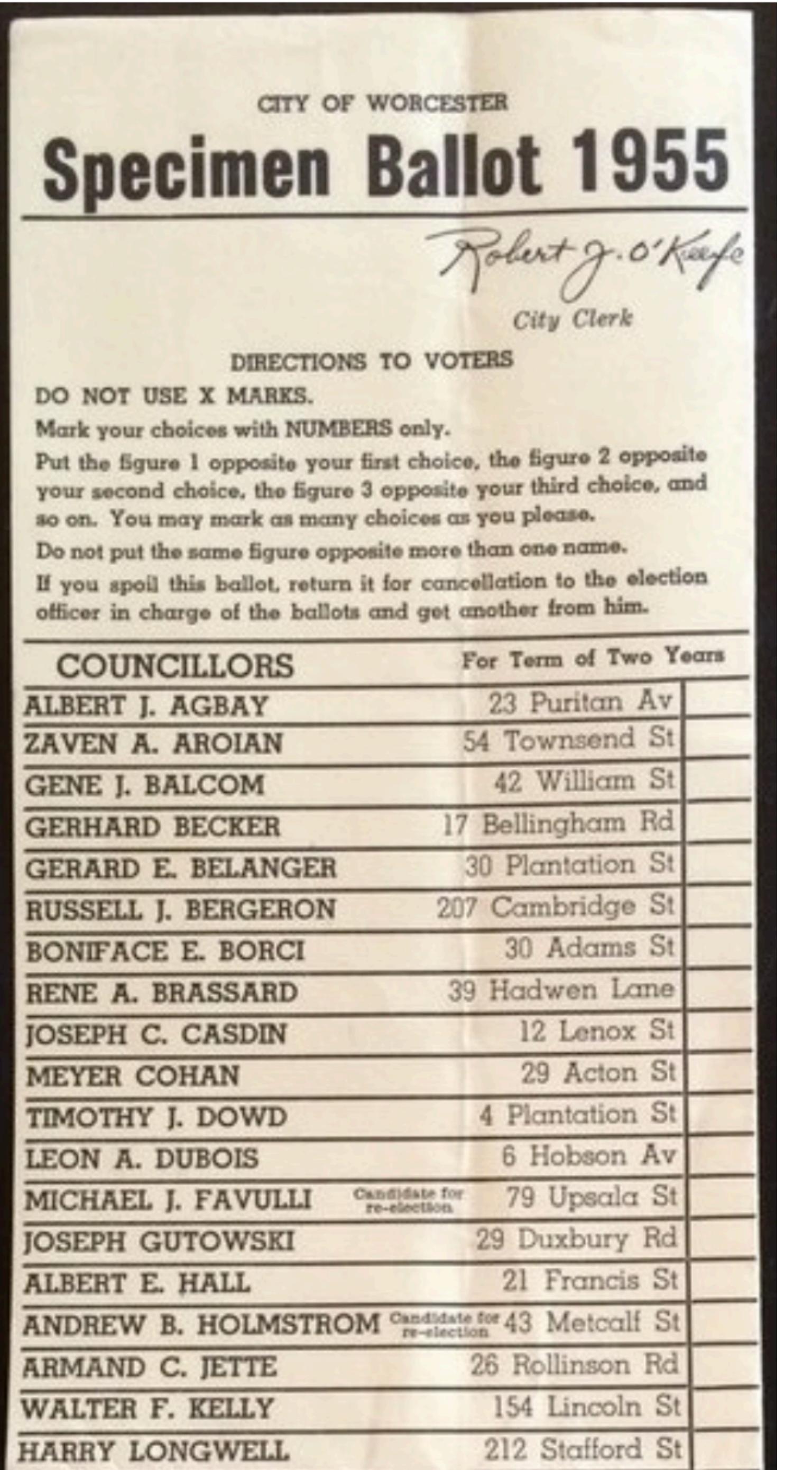


**presto!
proportionality**

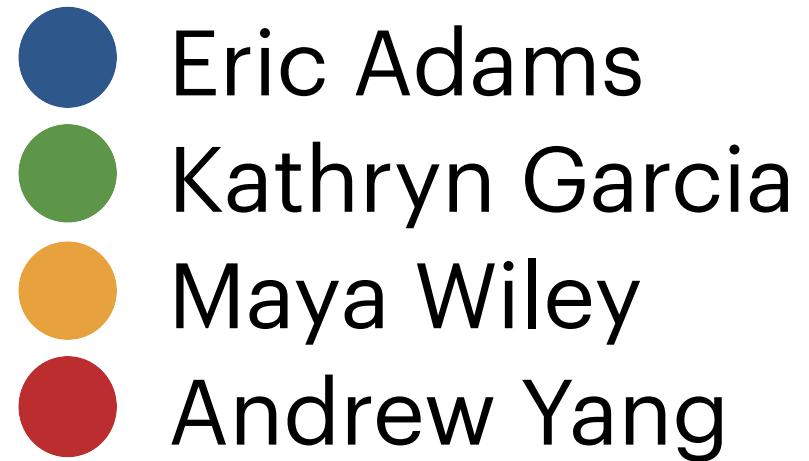
(without parties)

**votes transfer
from those
elected or
eliminated**

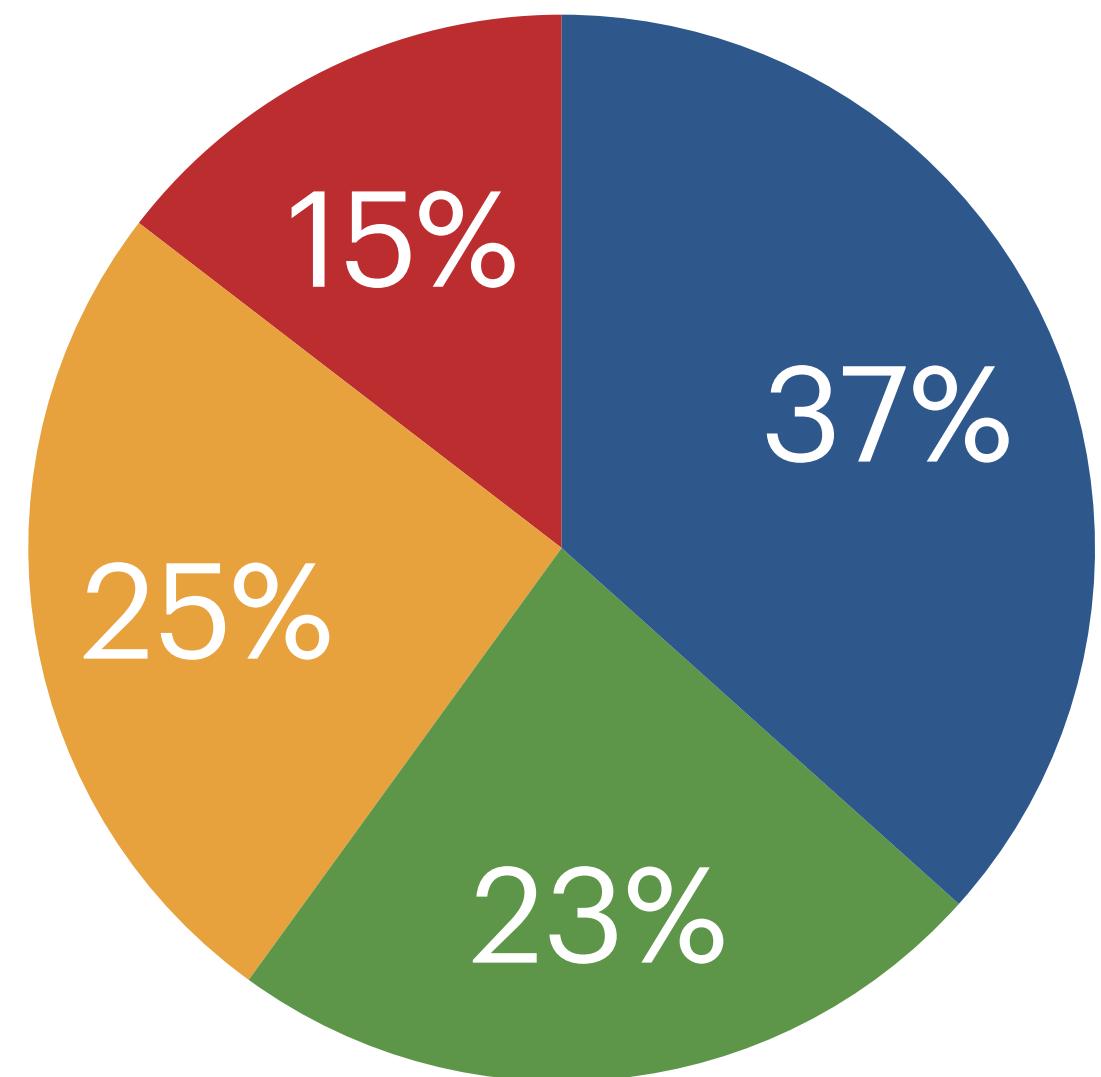
and in
real world?



IRV in action: NYC Mayor

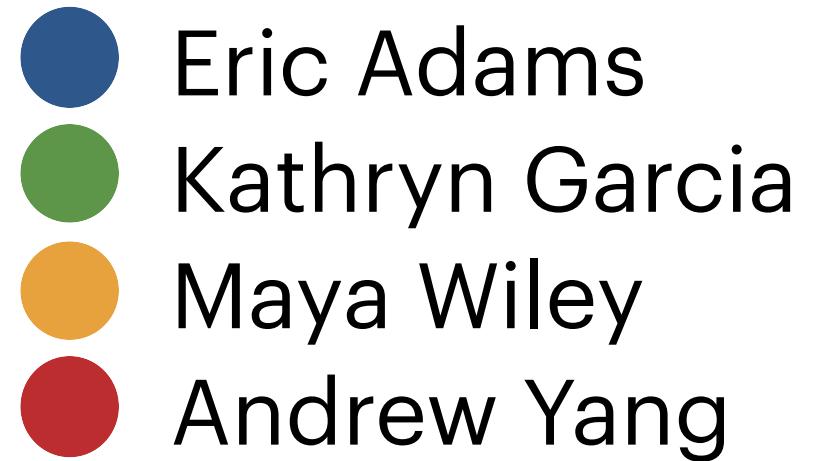


Round 1



in the first 5 rounds, write-ins and 9 named candidates are eliminated.

proportions for the top four barely change.

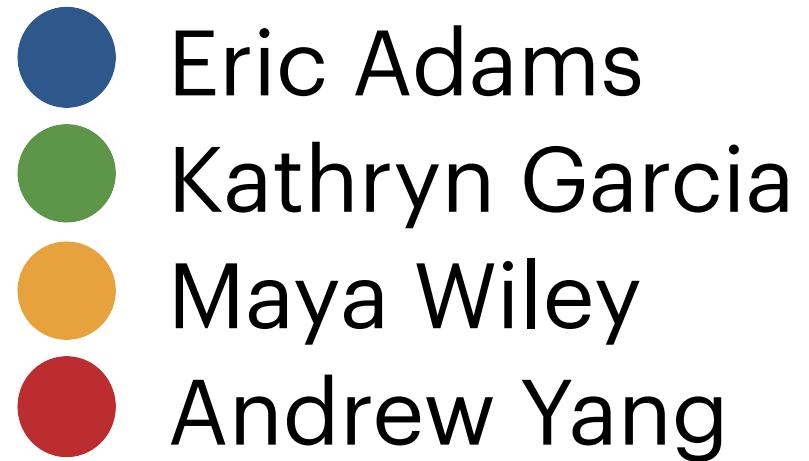


Round 7

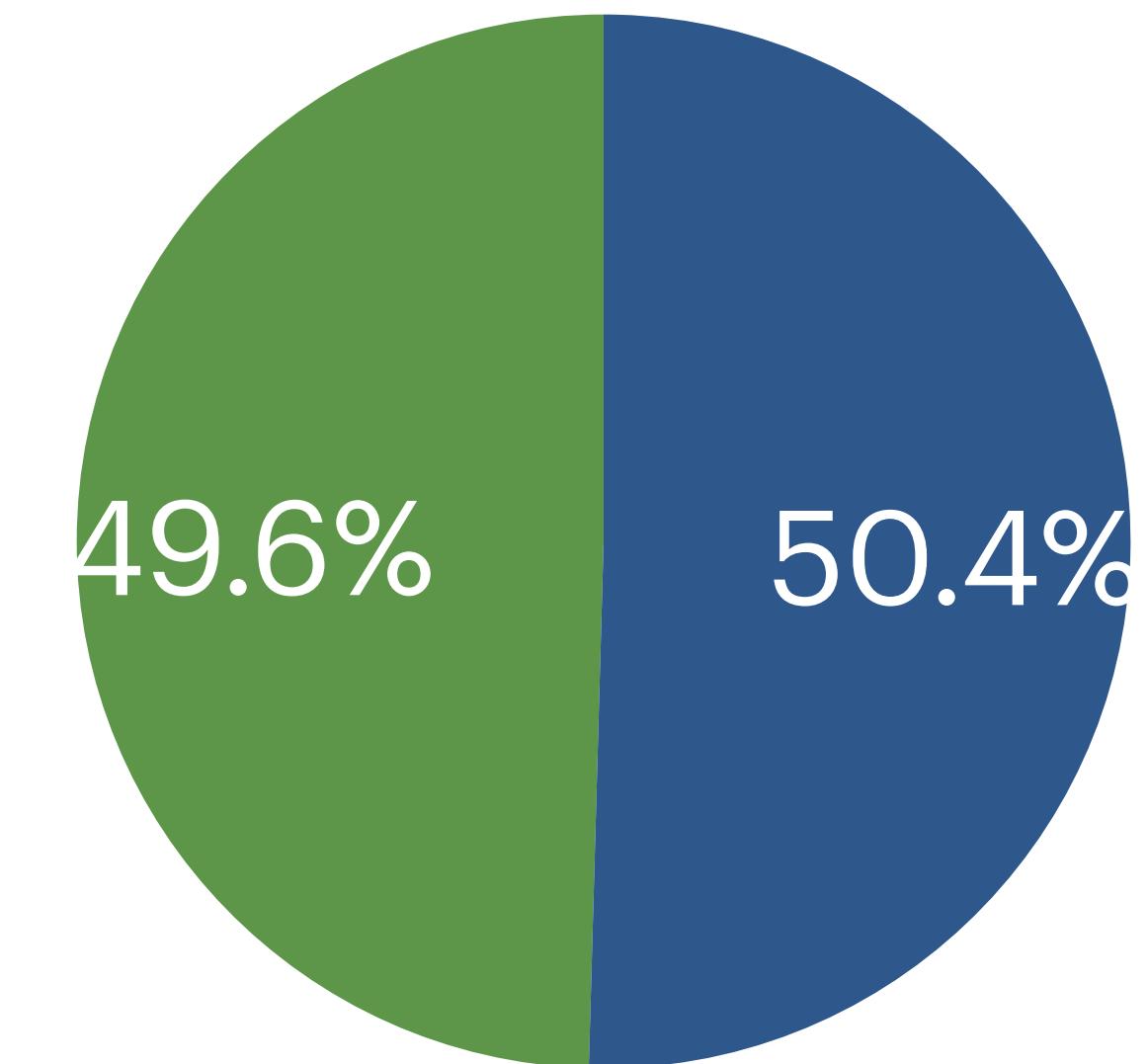


Wiley is eliminated. His 38K votes go to Adams, and just 16K to Wiley with the rest exhausted.

This leads Garcia to jump Wiley, and Wiley is next to be eliminated.

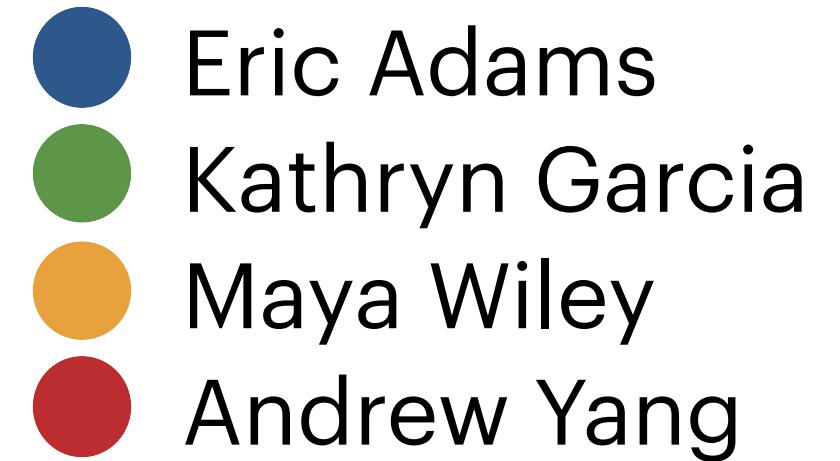


Round 8



Wiley's support breaks 2-to-1 for Garcia, but it's not enough!

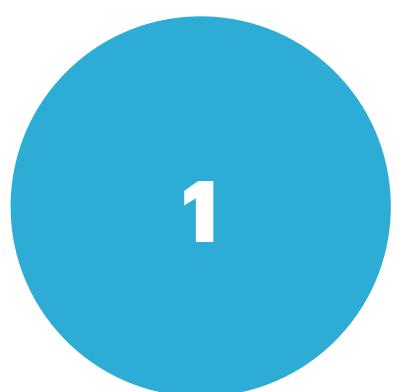
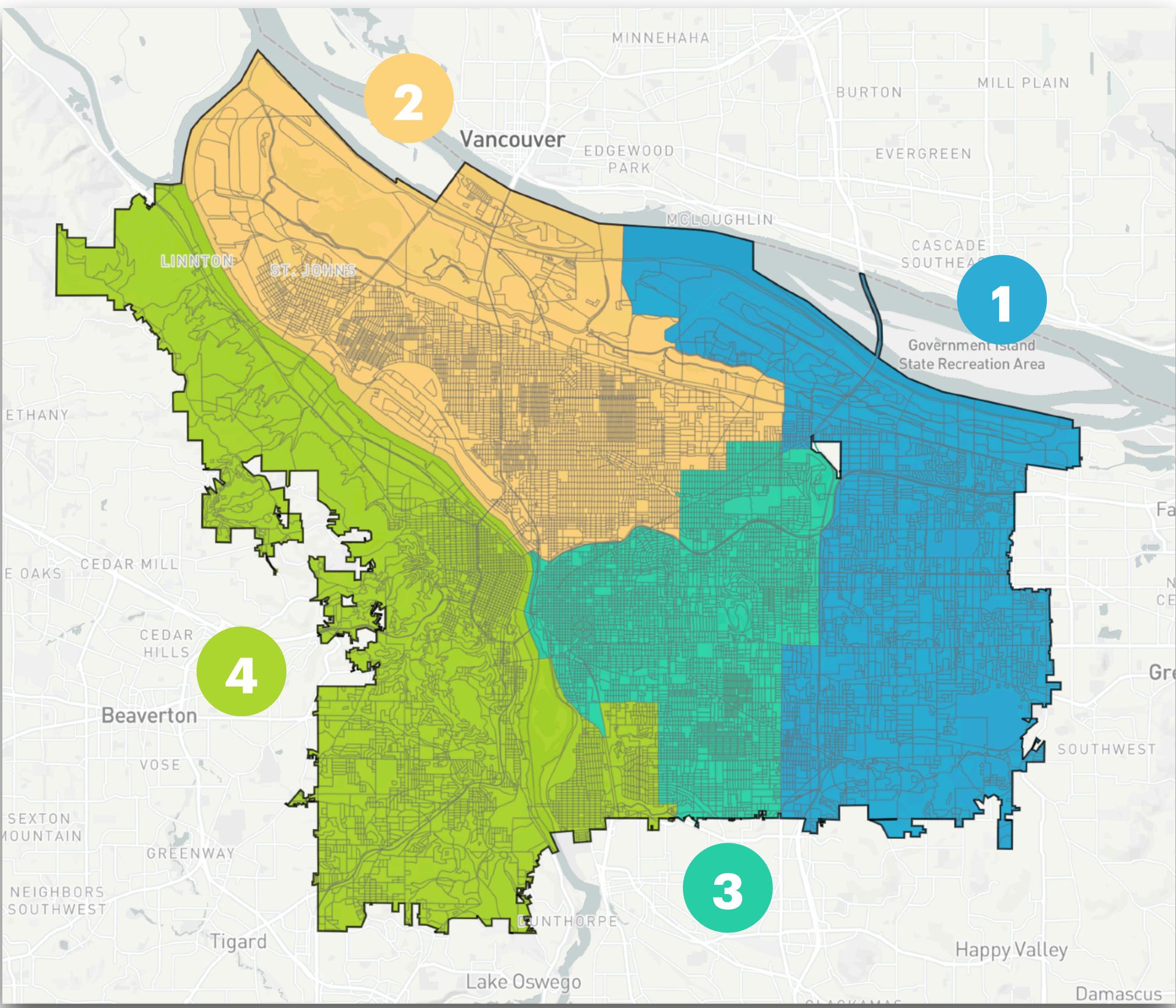
Adams is narrowly elected.

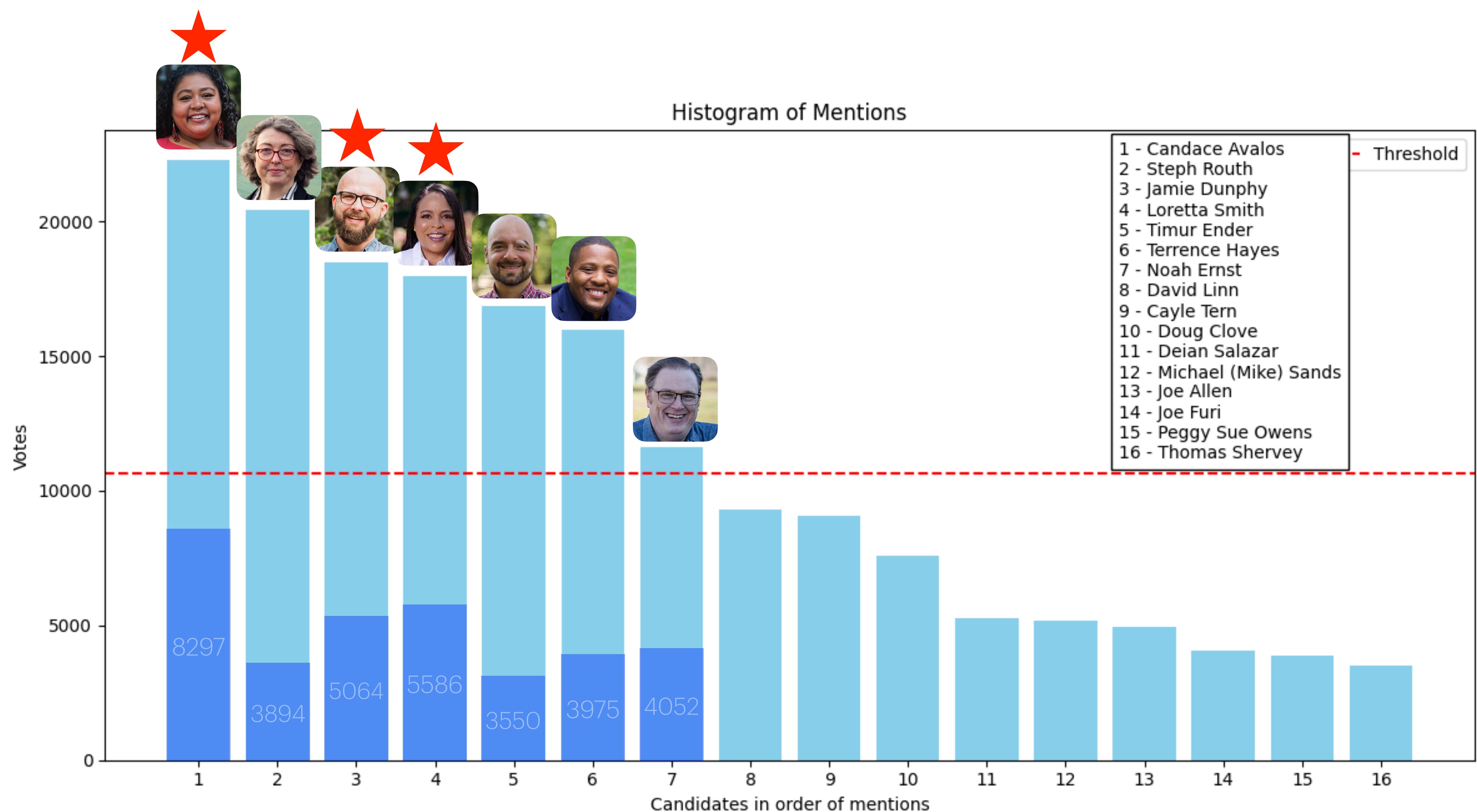


STV in action:
Portland city council

Portland, Oregon

- What just happened?
- **Zone 1:** 16 named candidates
 - Candace Avalos (B+H), Loretta Smith (B), Jamie Dunphy (W).
- **Zone 2:** 22 named candidates
 - Dan Ryan (W), Elana Pirtle-Guiney (W), Sameer Kanal (A).
- **Zone 3:** 30 named candidates
 - Steve Novick (W), Angelita Morillo (H), Tiffany Koyama Lane (A).
- **Zone 4:** 30 named candidates
 - Olivia Clark (W), Mitch Green (W), Eric Zimmerman (W).







10718



8297



5064



5586



3550



3975



4052

Round 1

10718



Round 10: only
viable are left.

10718



(Avalos super close)



Round 11:
Ender out

10718

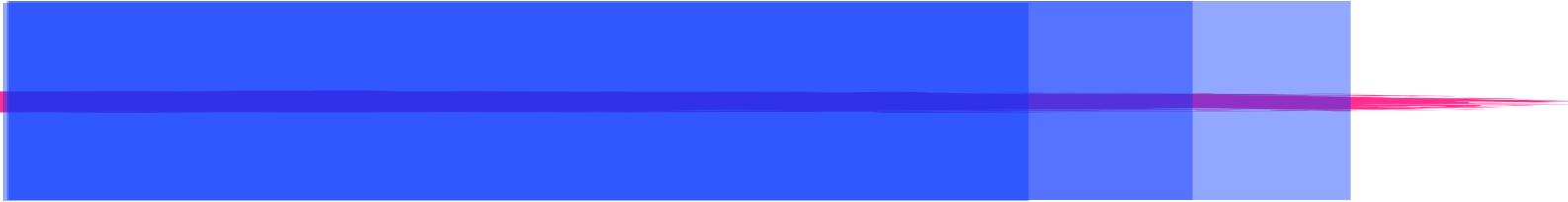
winner
#1



Round 12:
Routh out

10718

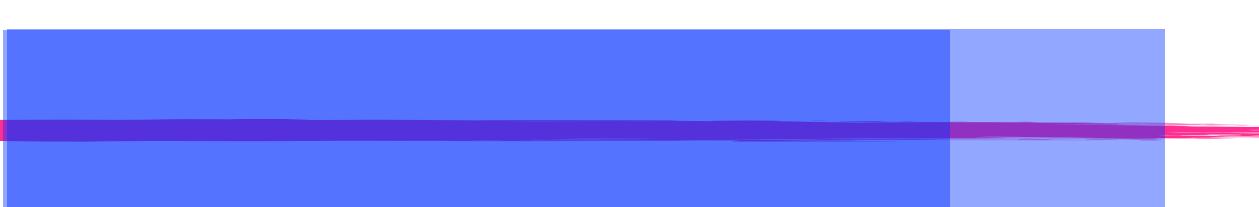
winner
#1



Round 13:
Avalos excess
distributed

10718

winner
#1



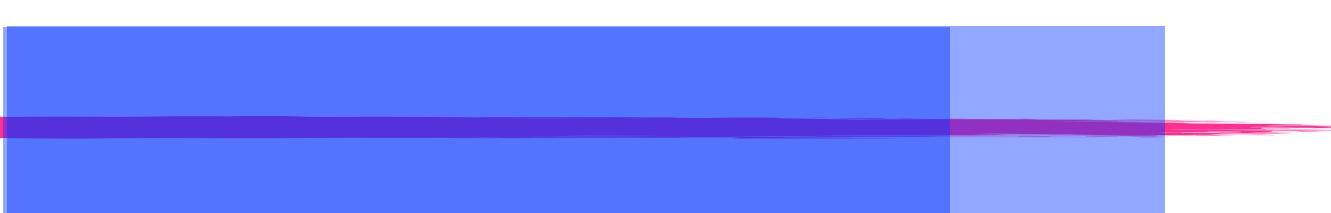
Round 14:
Ernst out

10718

winner
#1



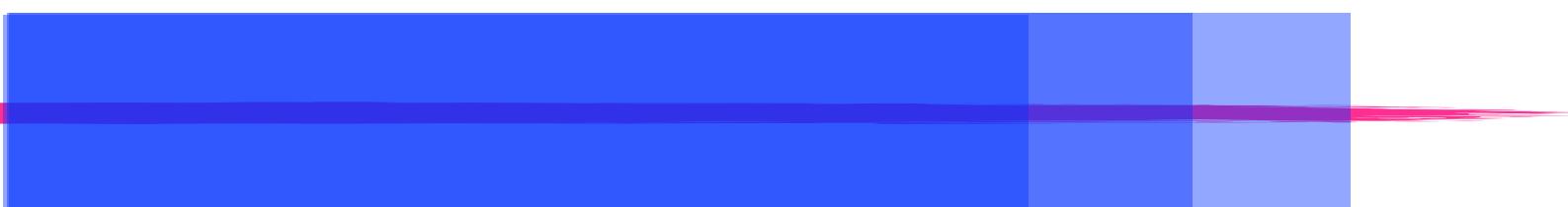
winner
#2



Round 15:
Hayes out

10718

winner
#1



winner
#3



winner
#2



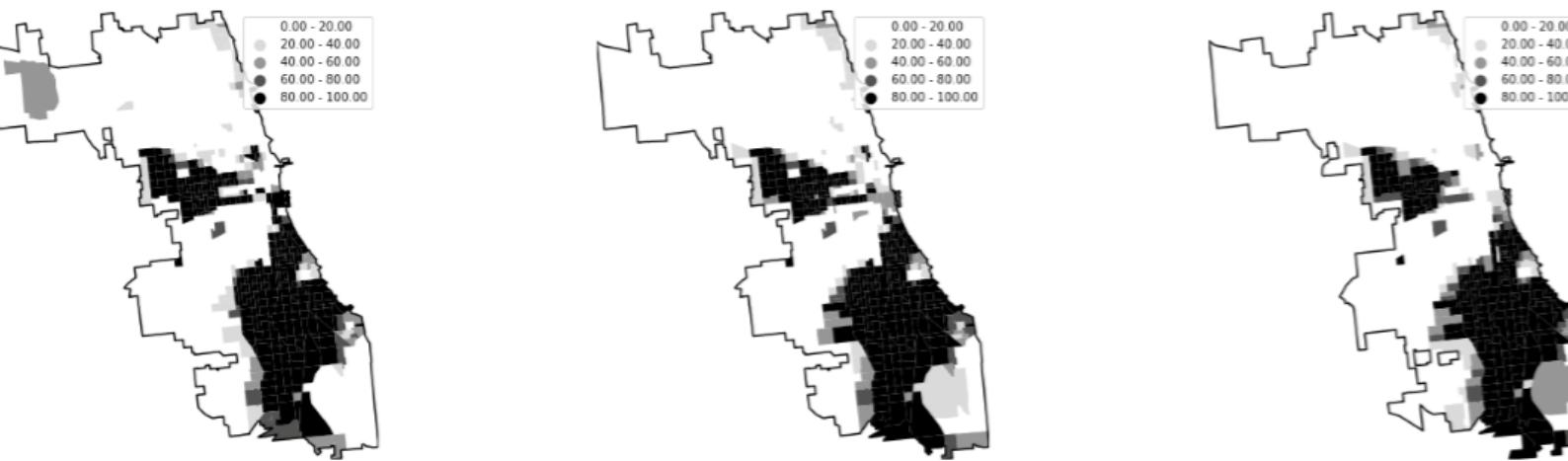
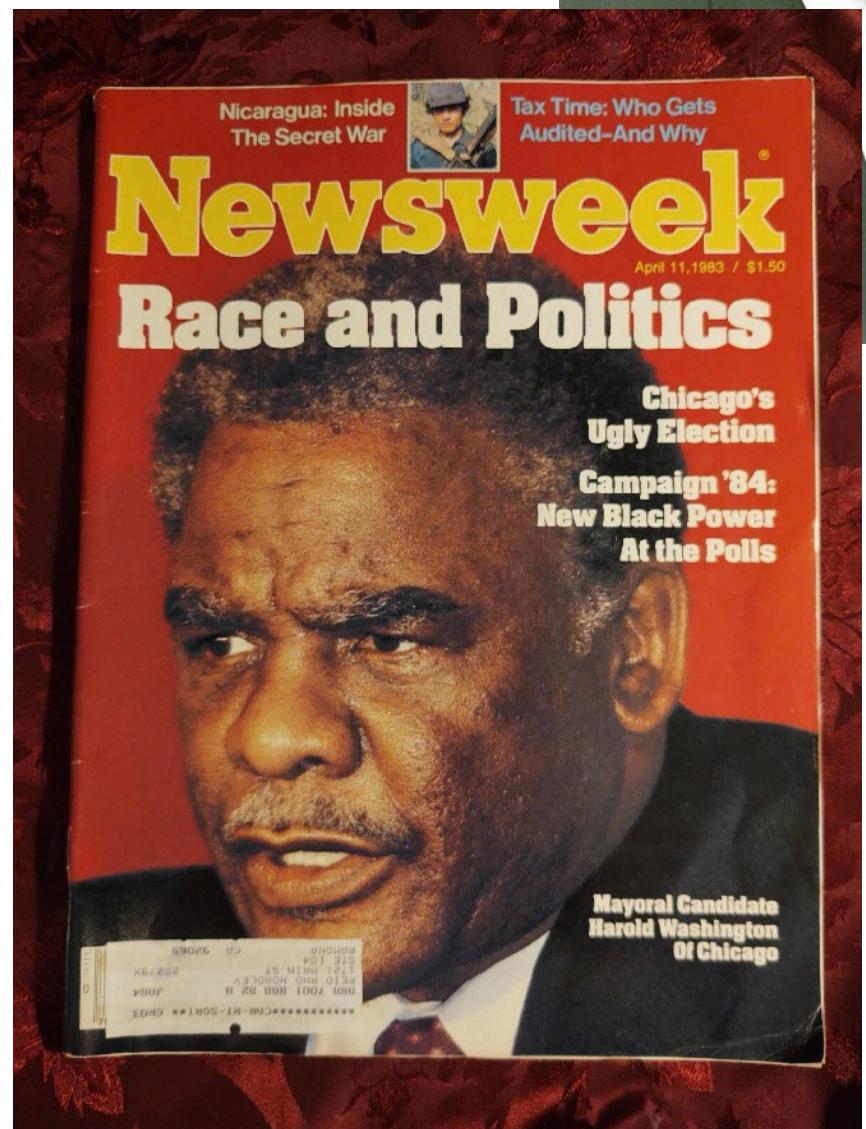
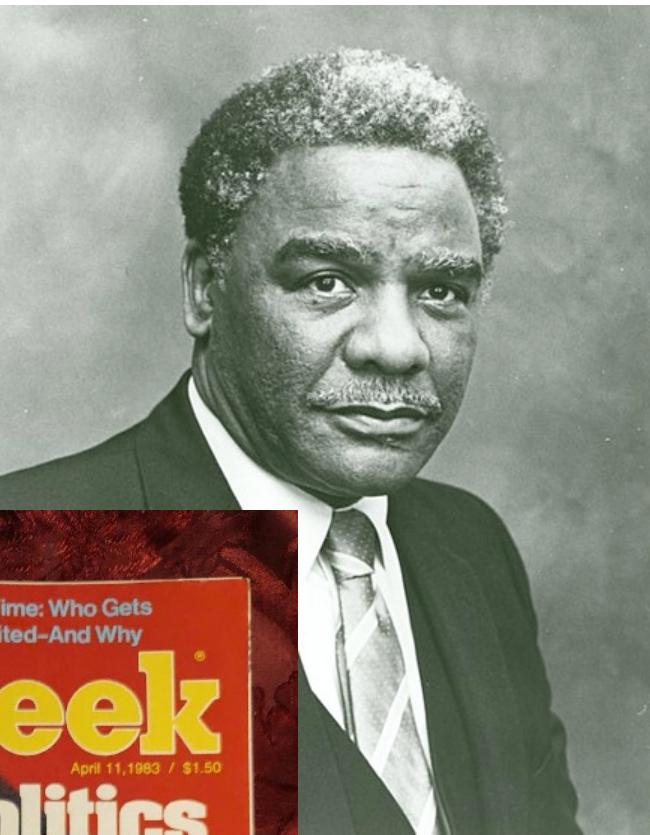
Dunphy doesn't cross threshold, but is elected as last candidate standing

Round 17:
Smith excess distributed

polarization

Then: Poster child for “White refusal” ...and now?

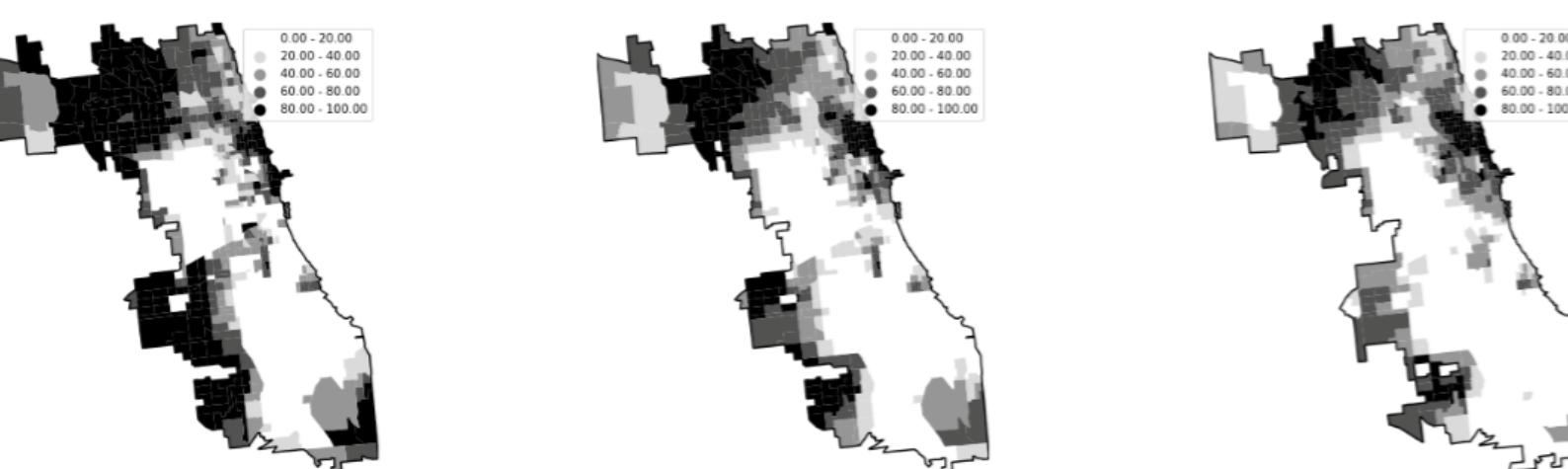
1983



(A) 1990, Black

(B) 2000, Black

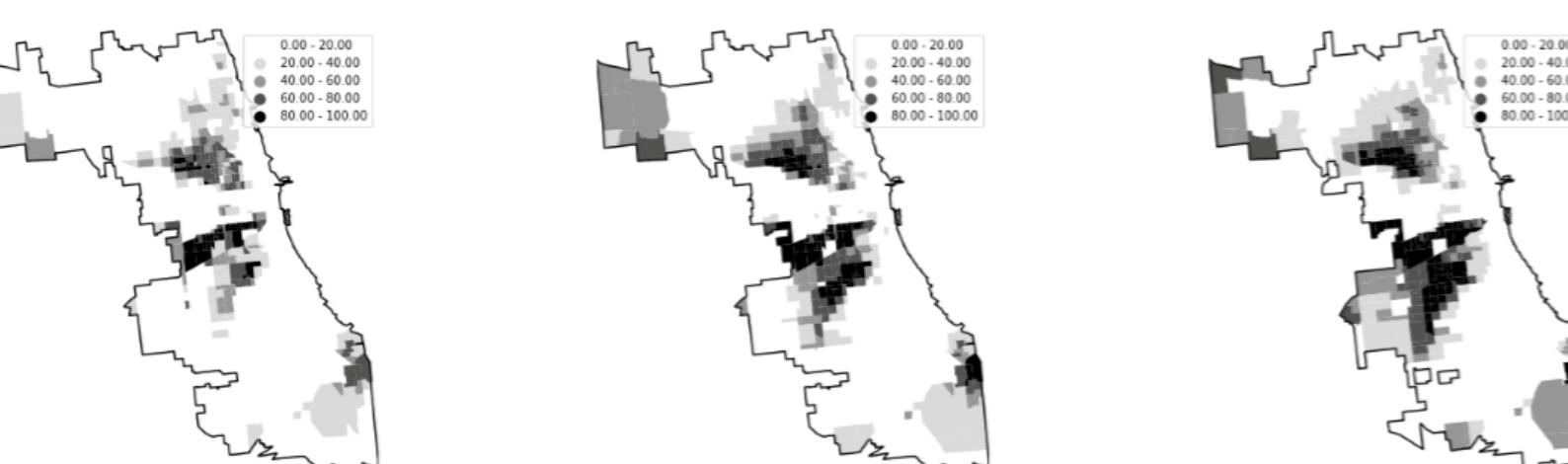
(C) 2010, Black



(D) 1990, White

(E) 2000, White

(F) 2010, White

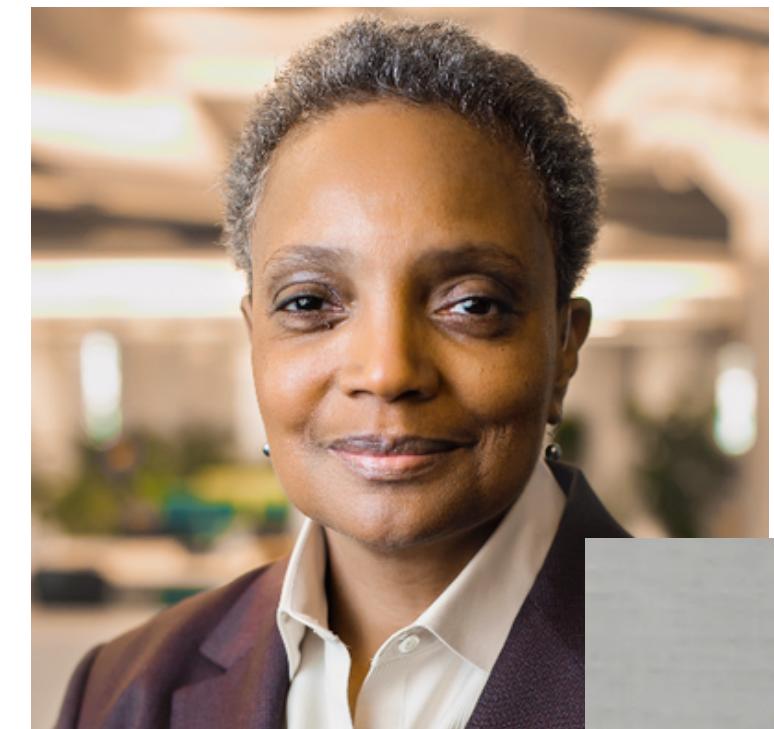


(G) 1990, Hispanic

(H) 2000, Hispanic

(I) 2010, Hispanic

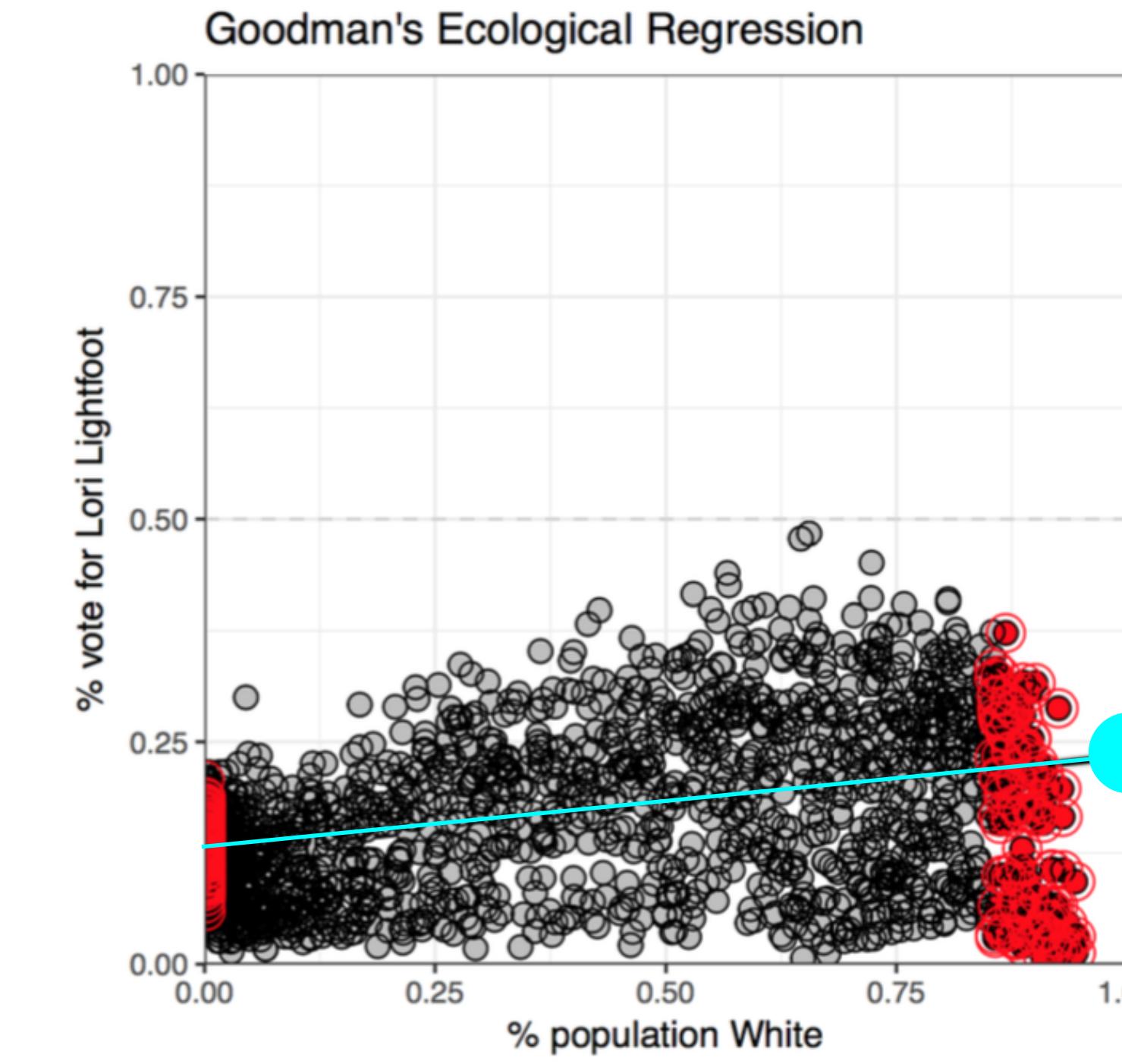
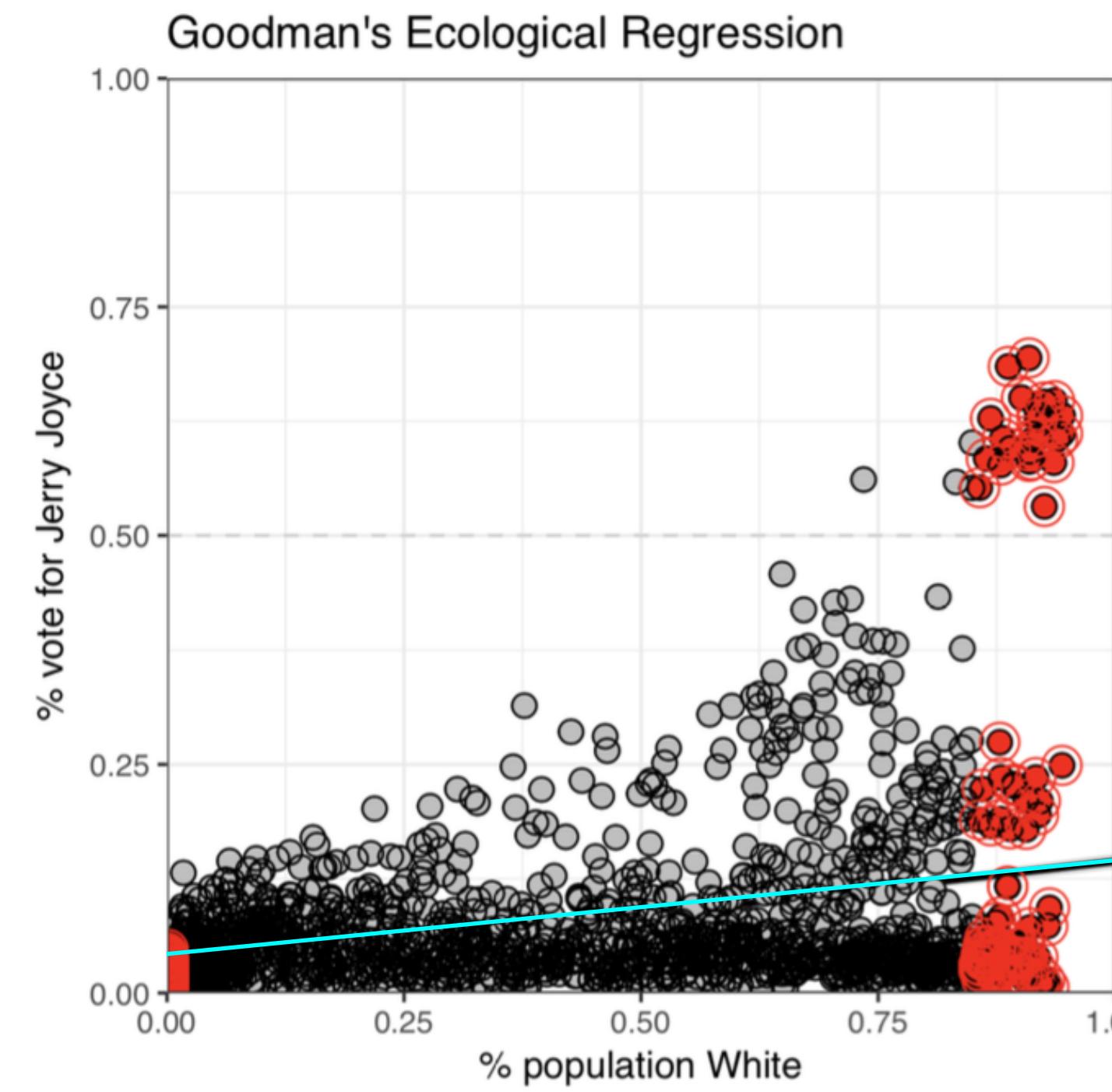
2010s-2020s



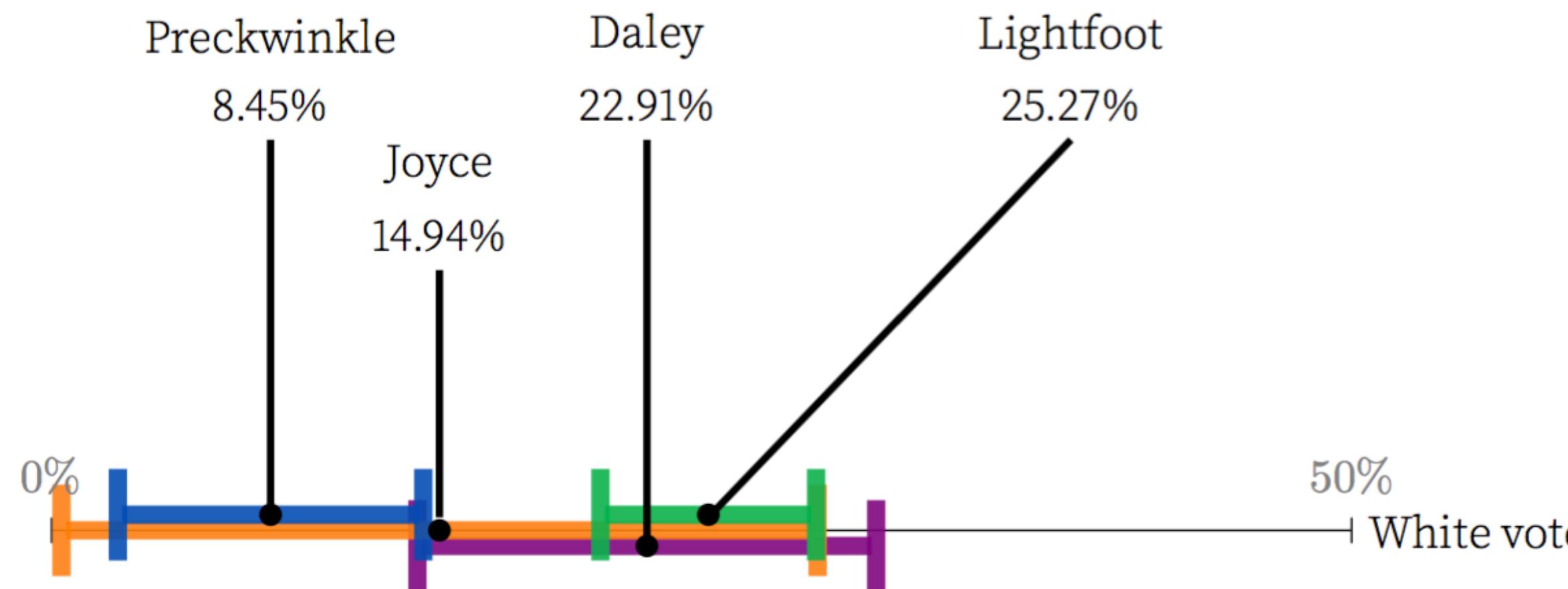
How to estimate polarization/cohesion?

- Statistical **inference**
 - Leading methods called **ER** (ecological regression) and **EI** (ecological inference)
- **Polls** and surveys
- or, **don't** estimate! Try different cohesion/crossover **scenarios** and see how results change.

ER/EI



Estimate:
About 25% of White
voters chose Lightfoot
in first round



Estimate:
About 25% of White
voters chose Lightfoot
in first round

22.1 VOTING POLARIZATION TODAY

Exit polls

These sex-by-race figures on presidential support come from CNN exit polls. They show interesting patterns around the country. (In blank cells, the number of people polled from that group was judged to be too small to produce a reliable estimate.)

National	White women	White men	Black women	Black men	Latina women	Latino men	All other
Clinton '16	43	31	94	82	69	63	61
Trump '16	52	62	4	13	25	32	31
Biden '20	44	38	90	79	69	59	58
Trump '20	55	61	9	19	30	36	38

This shows that Trump improved his relative standing in nearly every group from 2016 to 2020, while losing the popular vote by a larger margin. This is possible because White voters were estimated at 67% of the 2020 electorate, down from 71% in 2016.

AL	White women	White men	Black women	Black men	Latina women	Latino men	All other
Biden '20	19	23	93	82	-	-	-
Trump '20	80	74	7	18	-	-	-

CA	White women	White men	Black women	Black men	Latina women	Latino men	All other
Biden '20	51	51	-	75	77	73	68
Trump '20	47	47	-	21	22	24	28

MI	White women	White men	Black women	Black men	Latina women	Latino men	All other
Biden '20	49	39	95	88	-	-	66
Trump '20	51	60	5	11	-	-	30

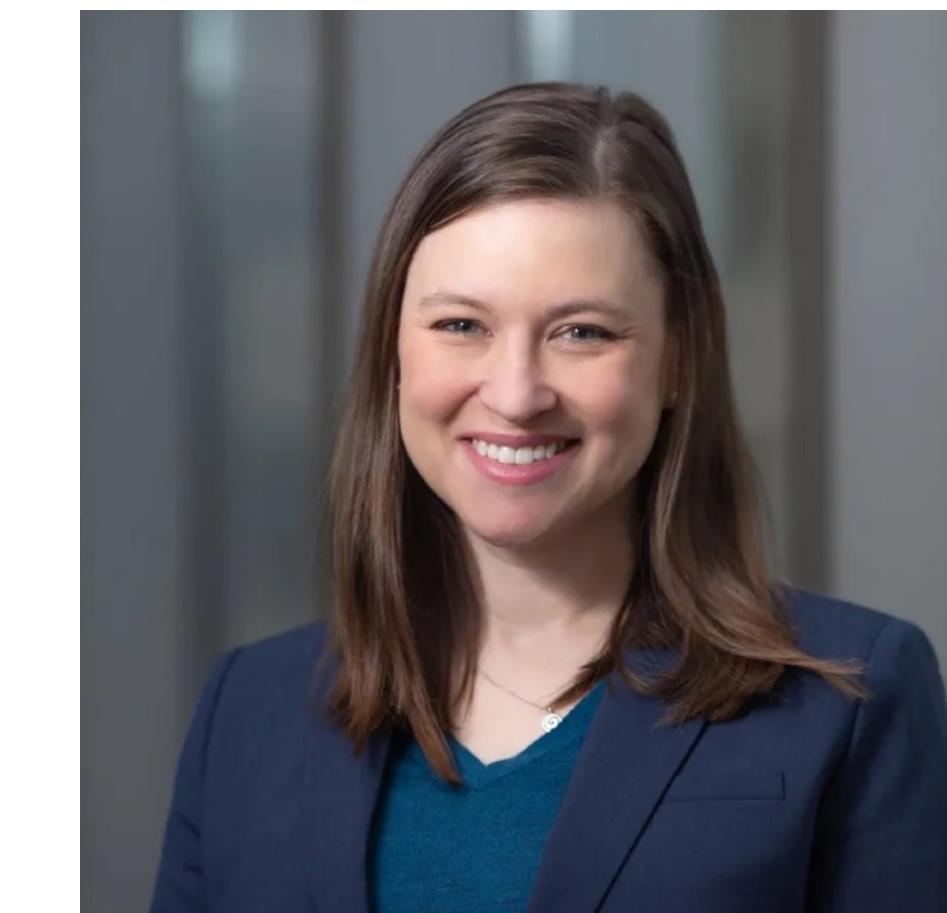
Toggles

Polarization levels

- **Category 1 Polarization:** POC 95% and White 5% support for POC-preferred candidates;
- **Category 2 Polarization:** POC 90% and White 20% support for POC-preferred candidates;
- **Category 3 Polarization:** POC 75% and White 20% support for POC-preferred candidates; and
- **Category 4 Polarization:** POC 60% and White 40% support for POC-preferred candidates.

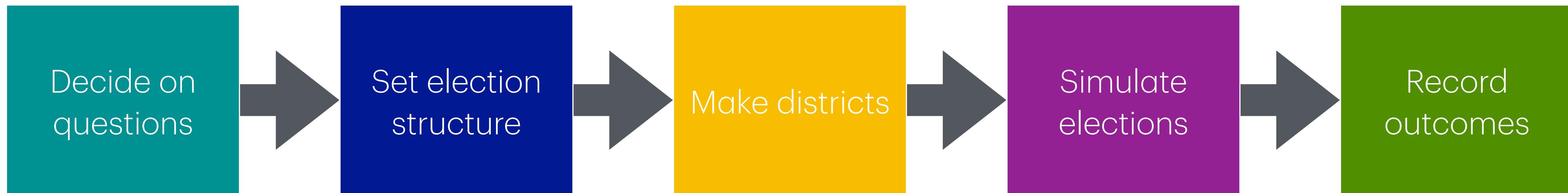


We came up with these in conversation with
Ruth Greenwood, CLC litigation veteran



YMMV

designing a study



EXAMPLES

Latino representation

low-income districts

entrenchment

IRV vs STV

10x3 STV

50 wards

10x5 STV

**10x5 STV vs.
50x1 IRV**

10 districts built out of CA

50 districts built out of precincts

vary districts and candidate pools

10-district and 50-district sets

simulate votes, run STV

—

est. probabilities from district features

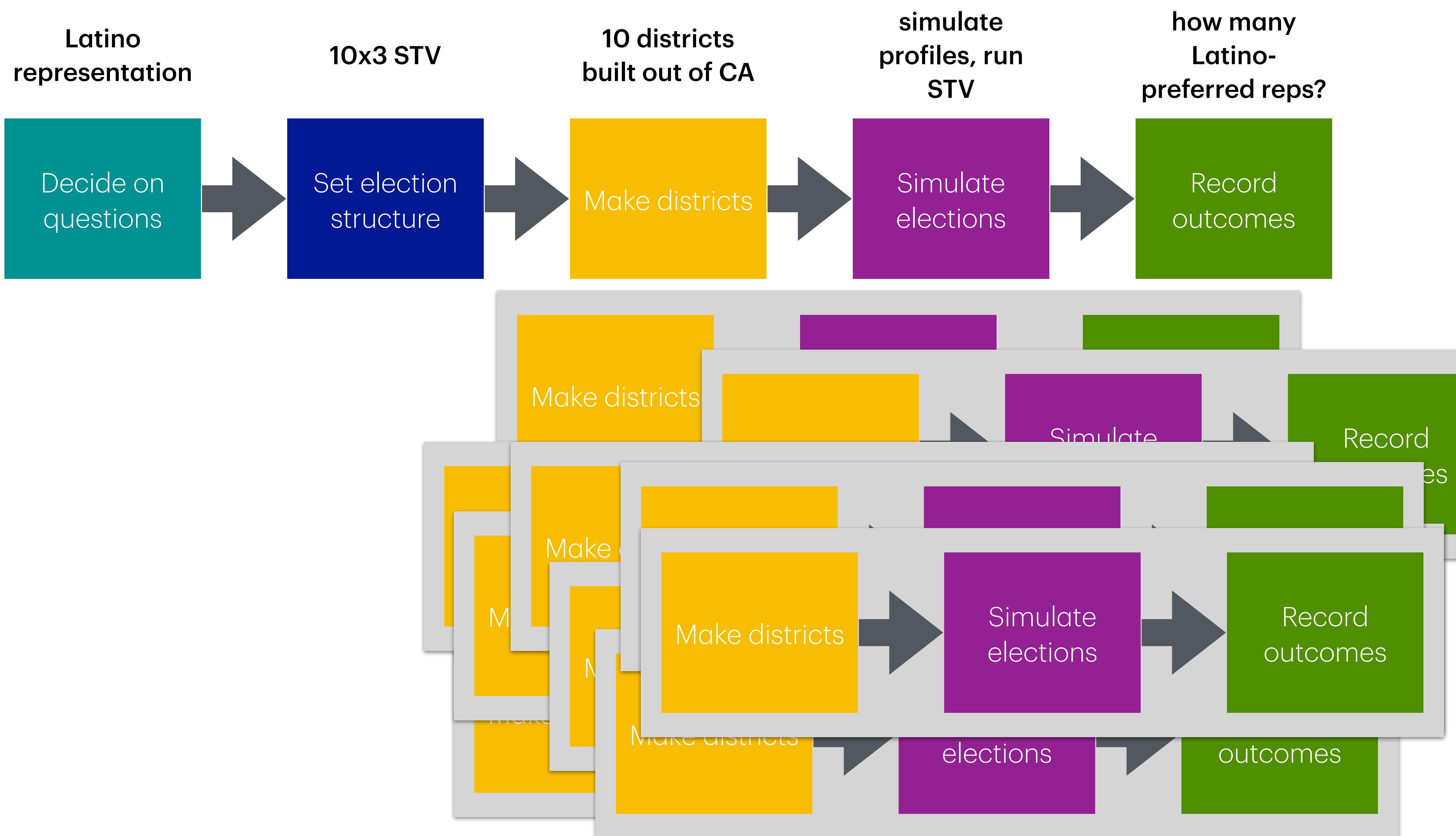
run methods on parallel voting profiles

how many Latino-preferred reps?

how many w/ concentrated poverty?

how many new reps?

how many POC-preferred reps?



Black Latino White Asian

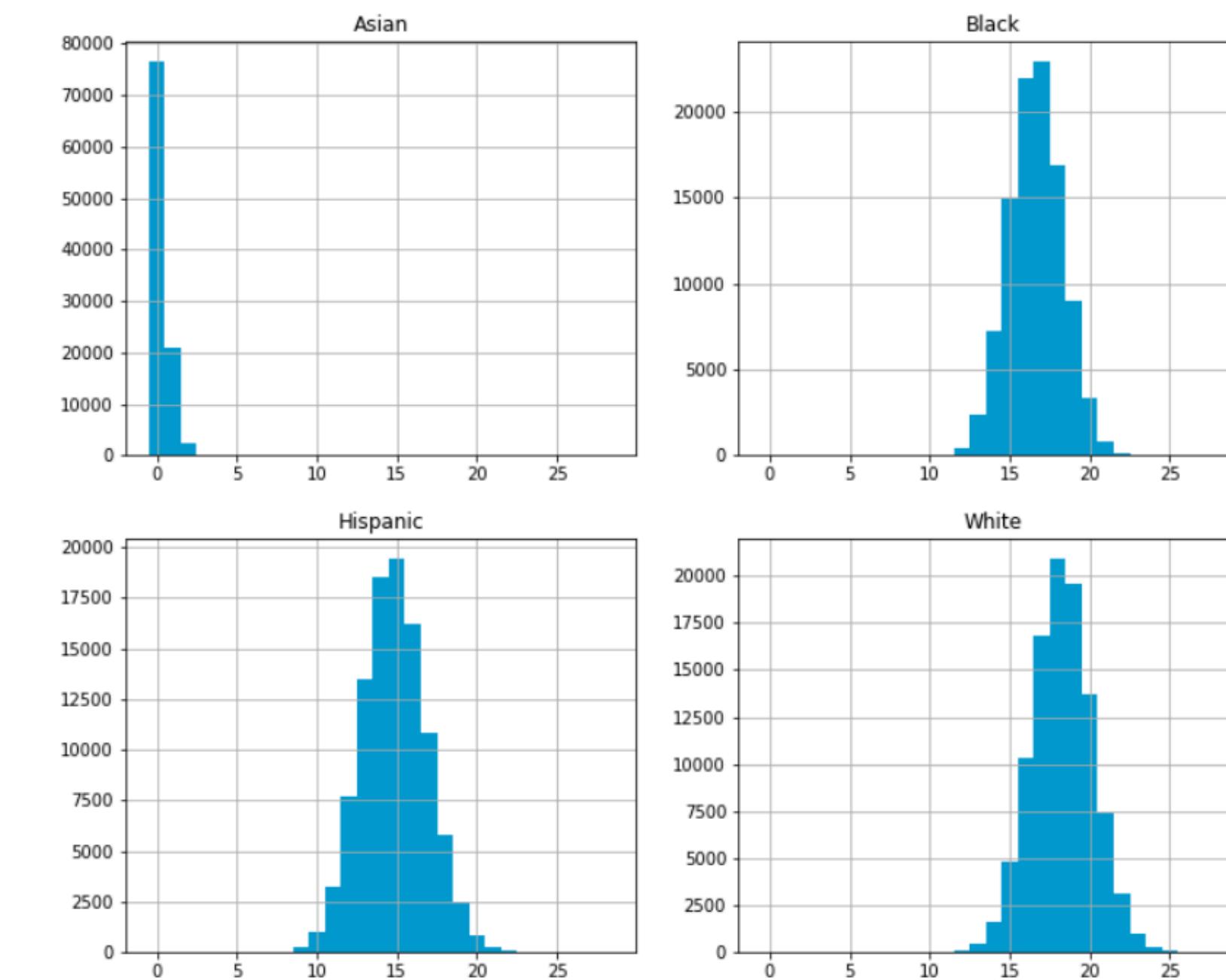
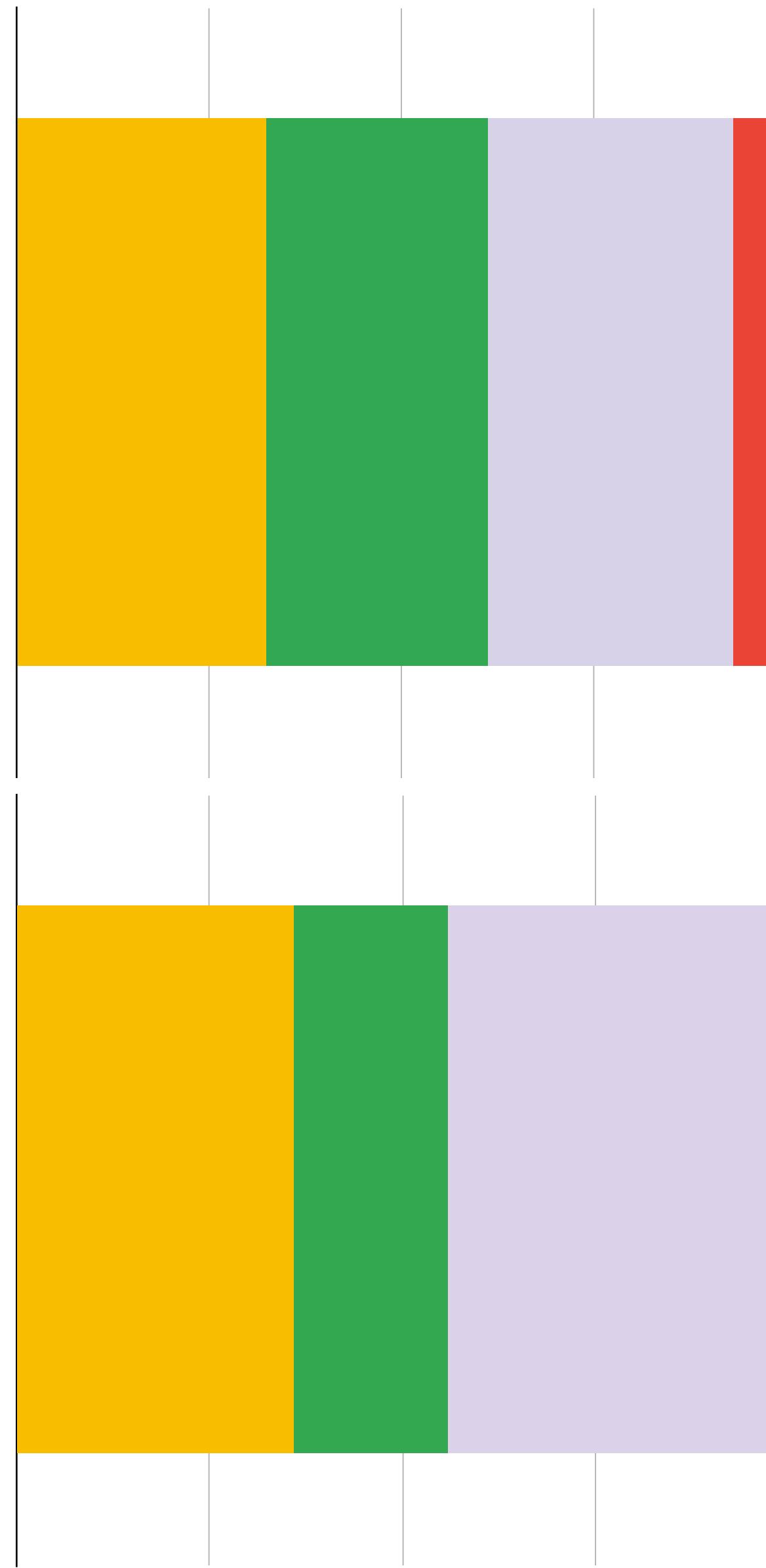
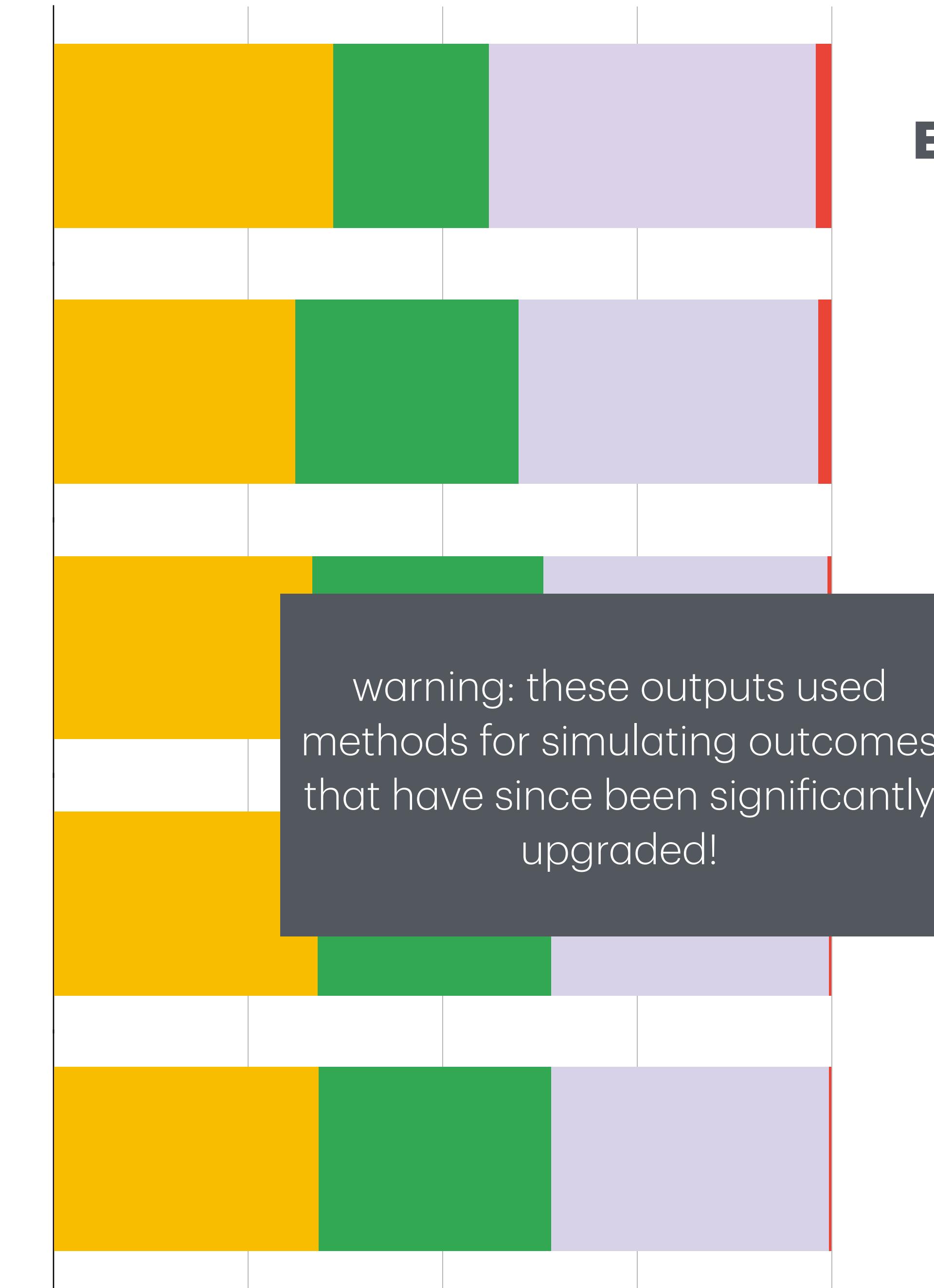


Figure 8. Results of 100,000 simulated elections in our $10 \times m$ ensemble with $m = 5$, showing how many members of each racial group are projected to be elected out of 50 aldermen in this election system.

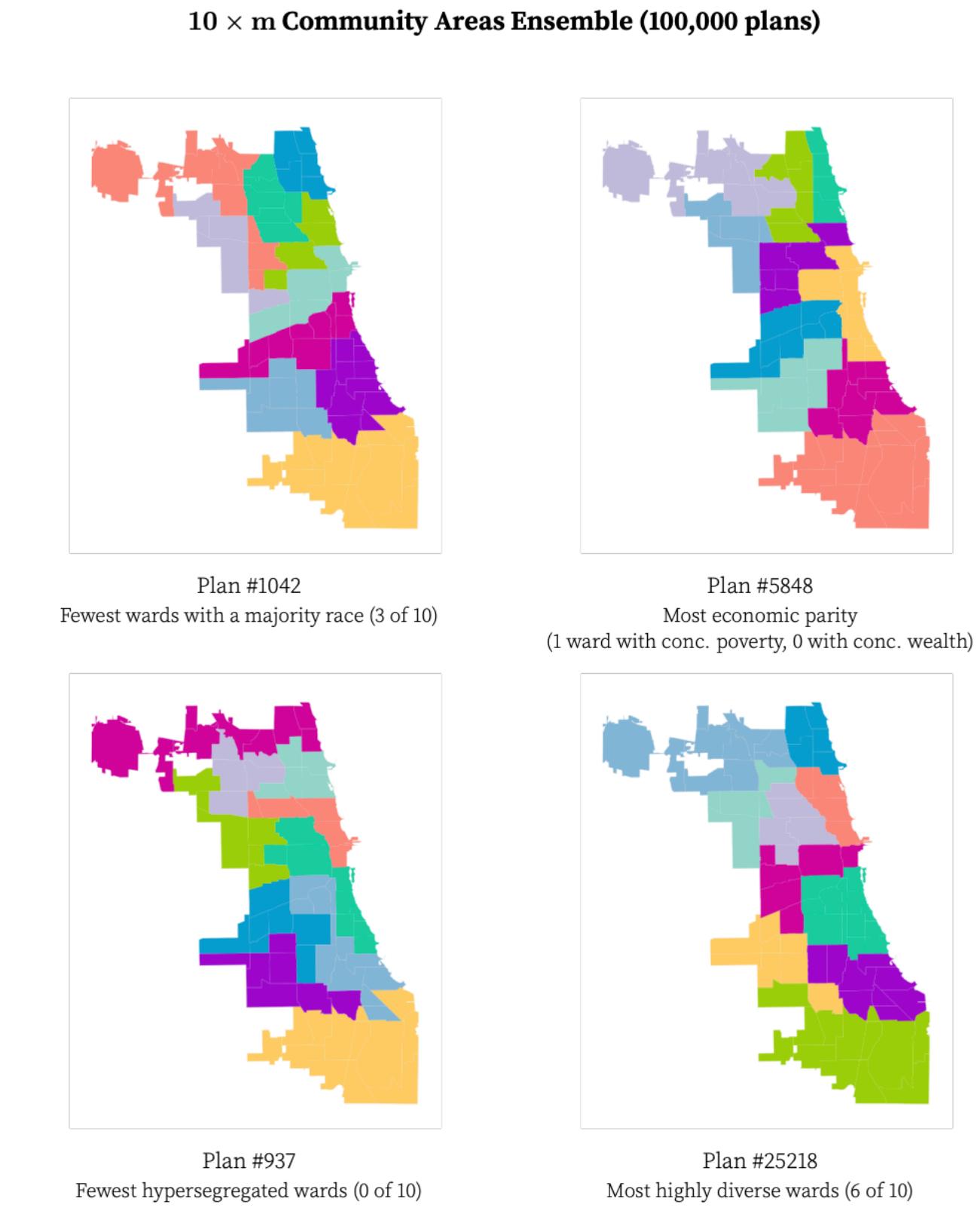
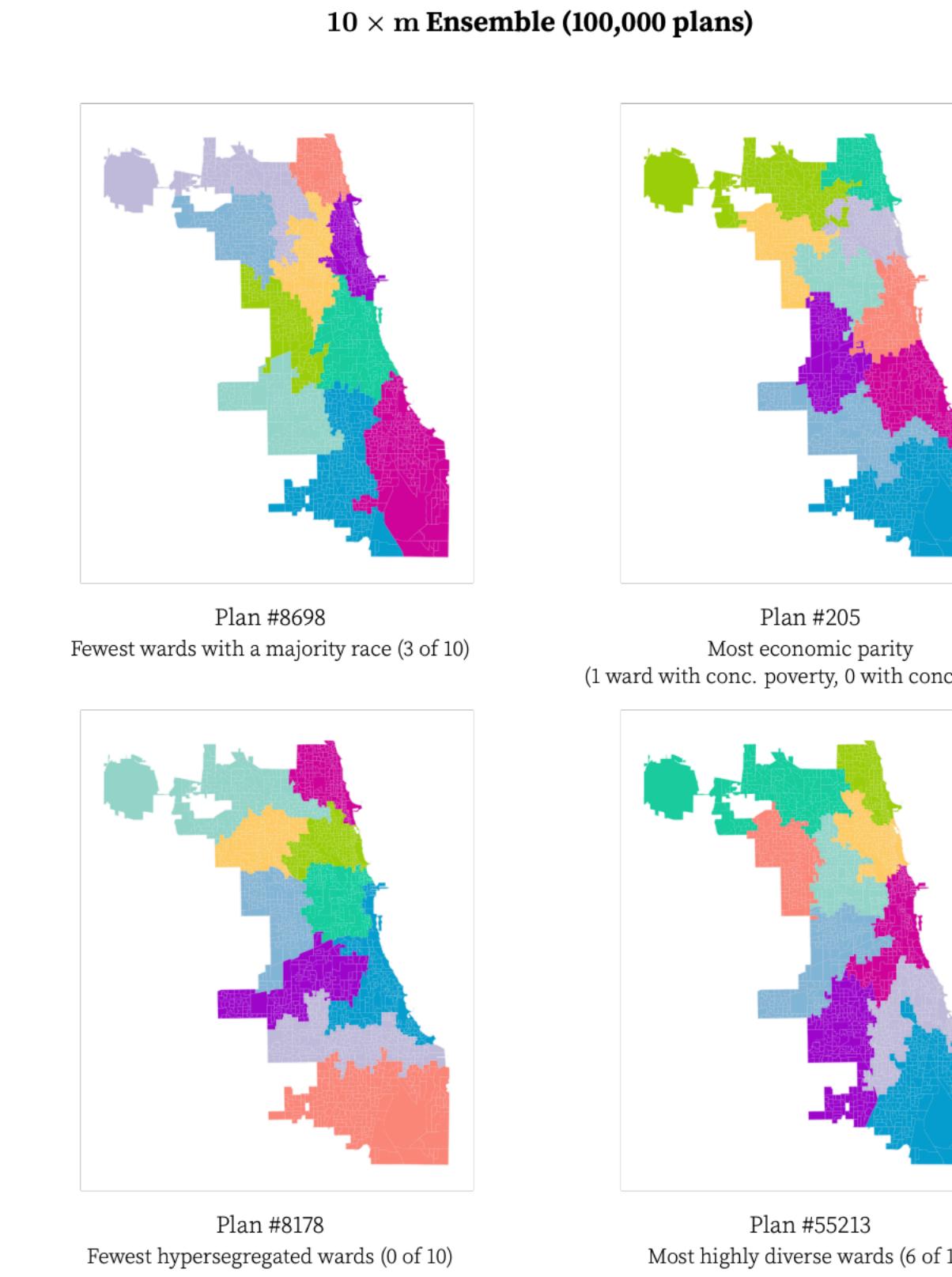
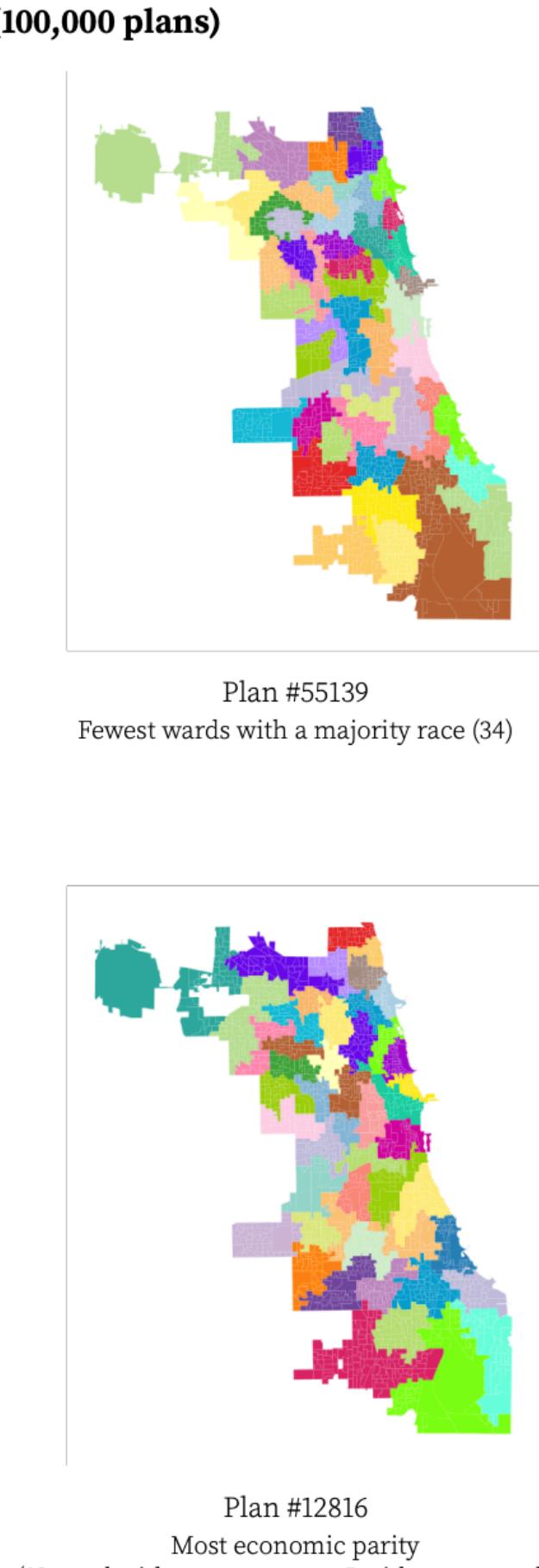
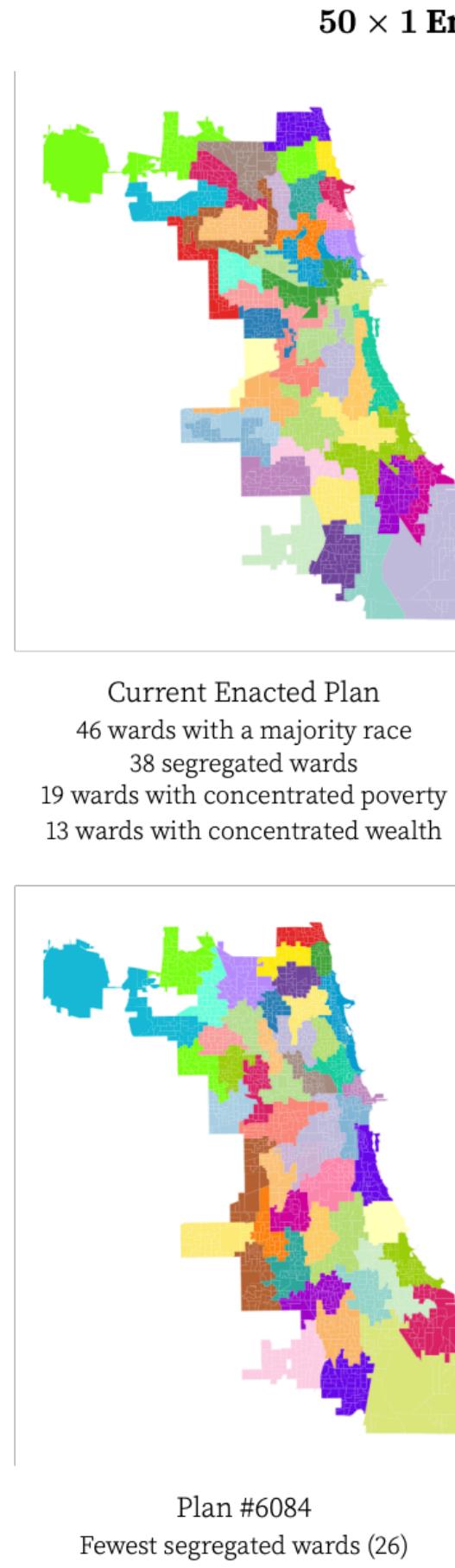
Black Latino White Asian



CITY 2010
ELECTED 2015



Surprise! no “cost” to keep CA together

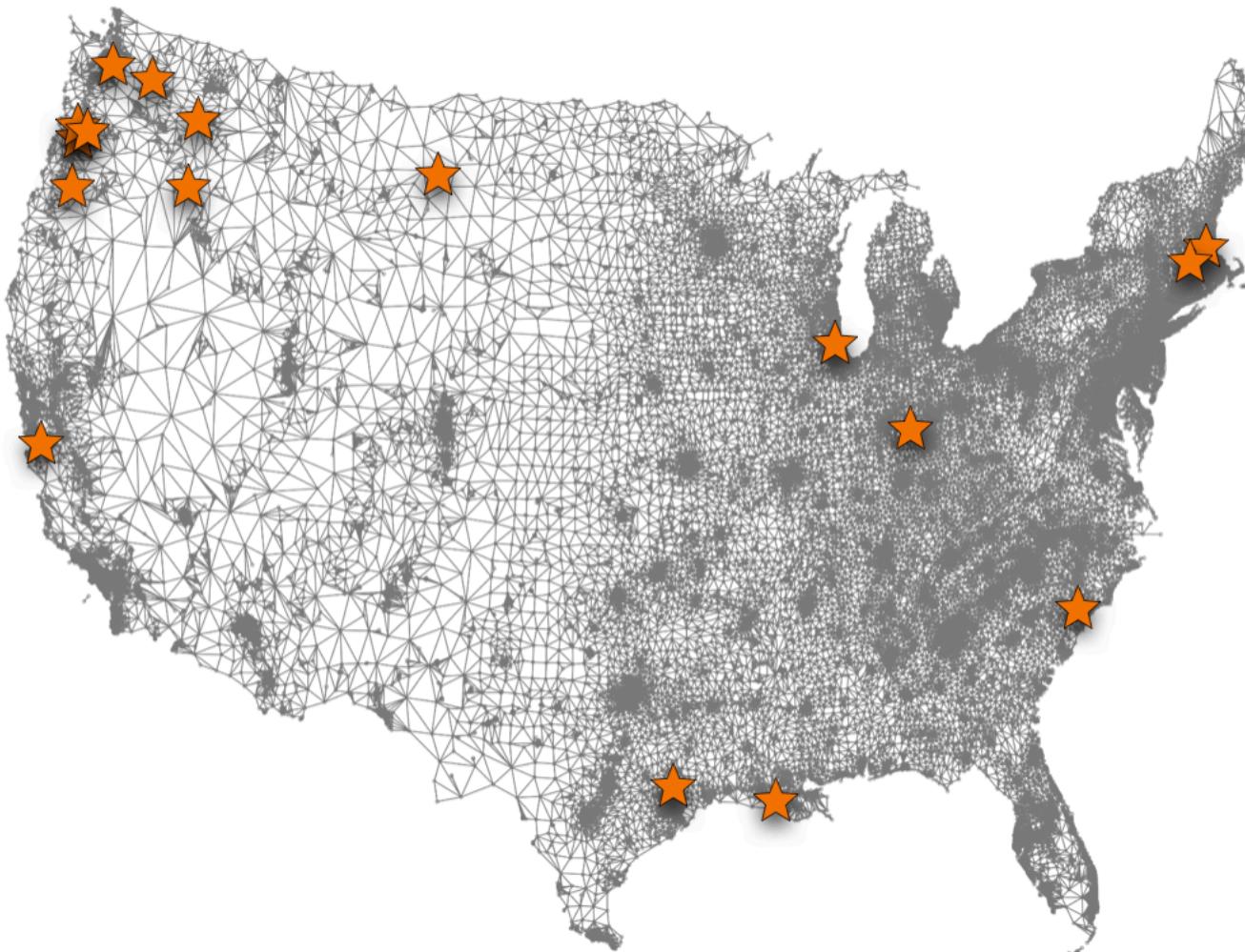


"Concentrated poverty": ≥ 25% of households under \$20K annual income; "Concentrated wealth": ≥ 25% of households over \$150K annual income; "Segregated": only one racial group exceeds 1/4 of population; "Hypersegregated": only one racial group exceeds 1/6 of population; "Highly diverse": three racial groups exceed 1/4 of population

a couple other examples!

Case studies

- Over the years since the Chicago study we've put a huge amount of effort into developing **better models of how people vote**
- Successively improving methods over the course of many **case studies**



- Chicago (Apr 2019) - <https://mggg.org/chicago>
- Lowell, MA (Oct 2019) - <https://mggg.org/lowell>
- Yakima, WA (Jan 2020) - brief report supporting CLC letter - <https://mggg.org/yakima>
- Pasadena, TX;
- Jones County, NC;
- Terrebonne Parish, LA; and
- Cincinnati, OH (Feb 2021)
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3778021
- Washington (July 2021) - <https://mggg.org/publications/Washington.pdf>
- Oregon (July 2021) - <https://mggg.org/publications/Oregon.pdf>
 - Portland (July 2021) - <https://mggg.org/publications/Portland.pdf>
 - Beaverton School District (July 2021) - <https://mggg.org/publications/Beaverton.pdf>
 - Hillsboro School District (July 2021) - <https://mggg.org/publications/Hillsboro.pdf>
 - Salem-Keizer School District (July 2021) - https://mggg.org/publications/Salem_Keizer.pdf
 - Chelan County (July 2021) - https://mggg.org/publications/Chelan_County.pdf
 - Pierce County (July 2021) - https://mggg.org/publications/Pierce_County.pdf
 - Tukwila School District (July 2021) - <https://mggg.org/publications/Tukwila.pdf>
 - Wenatchee School District (July 2021) - <https://mggg.org/publications/Wenatchee.pdf>
- FRA national study (July 2022) - <https://mggg.org/FRA-report> and supplement: <https://mggg.org/FRA-supplement>
- Massachusetts (Feb 2025) - <https://mggg.org/MA-report>

Washington

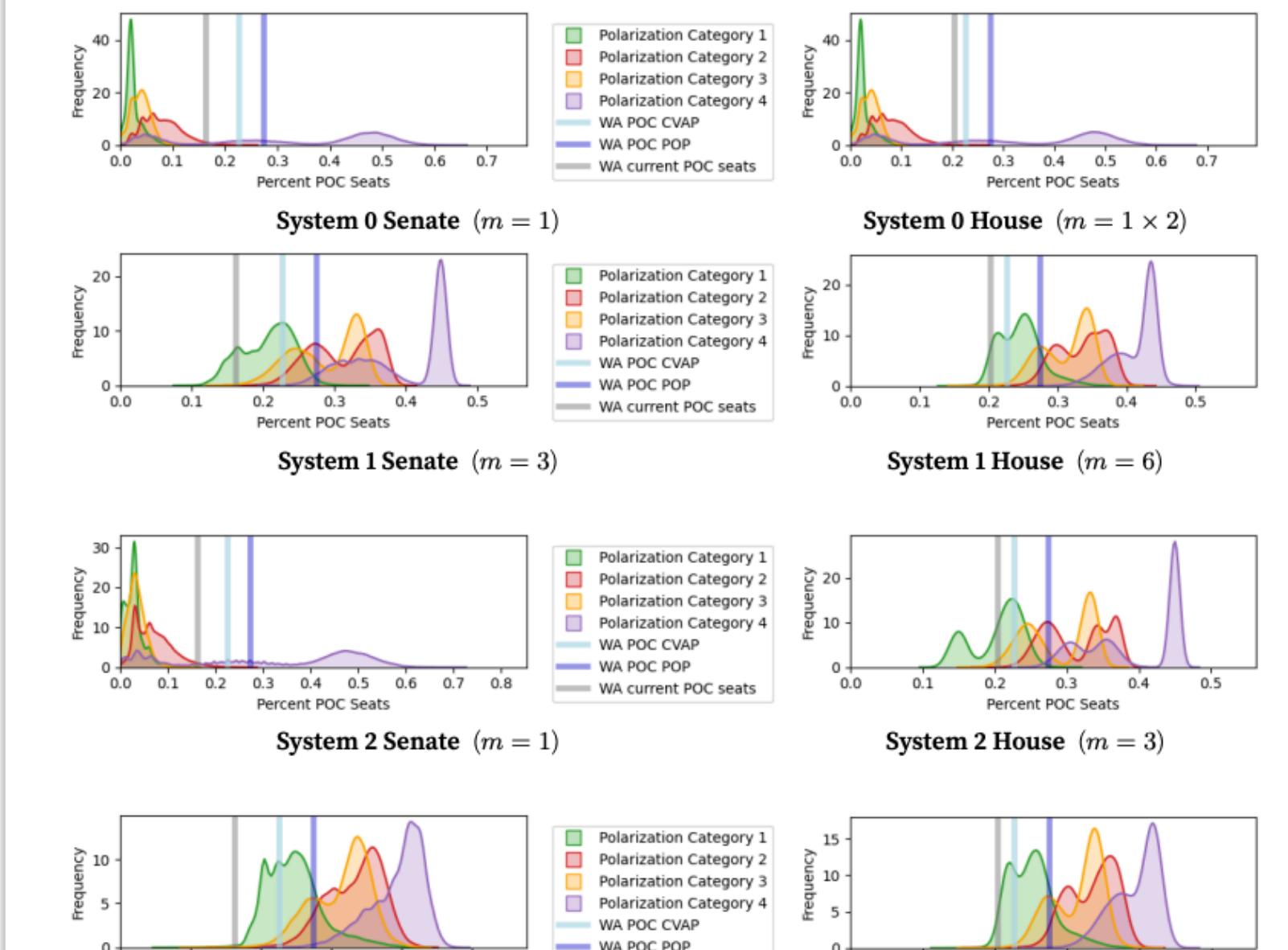
This one used ALL THE TOGGLES

- Electoral structure (especially m , the magnitude)
- Candidate pools (number, strength)
- Polarization
- Voter behavior

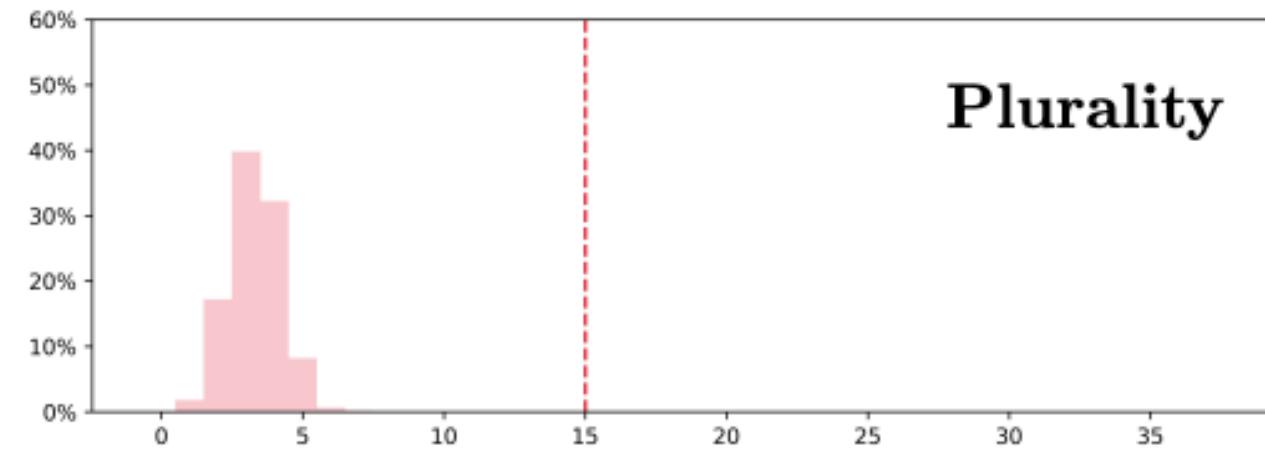
TL;DR

multi-member systems are reliably proportional
except under the most extreme polarization

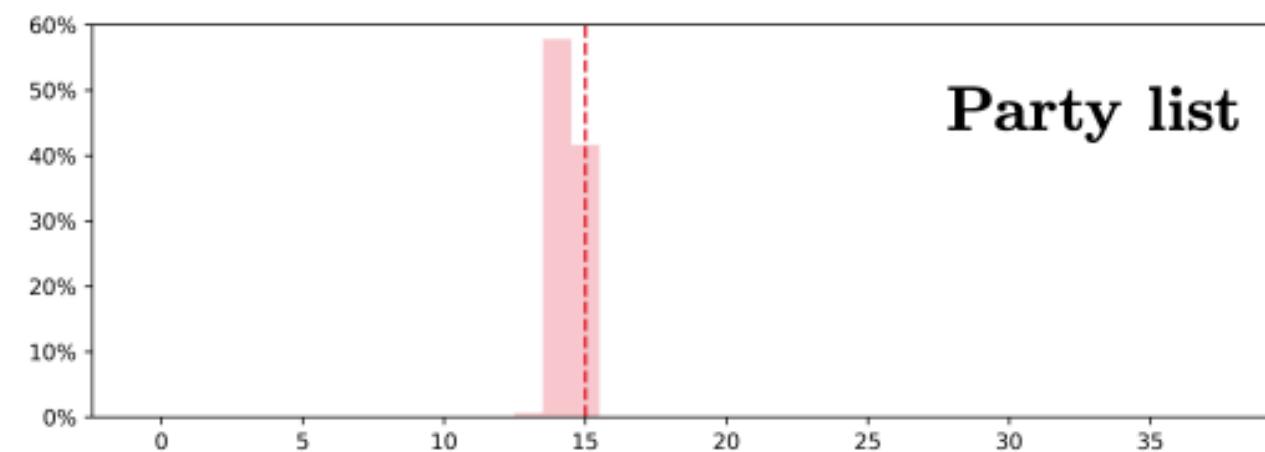
	Polarization Category	System 0 ($m = 1, 1 \times 2$)	System 1 ($m = 3, 6$)	System 2 ($m = 1, 3$)	System 3 ($m = 7, 7$)	System 4 ($m = 1$)	System 5 ($m = 5$)
Estimated POC-Preferred Senators	1	1-2 (of 49)	8-11 (of 48)	0-1 (of 33)	10-14 (of 49)		
	2	2-6 (of 49)	13-18 (of 48)	1-4 (of 33)	14-18 (of 49)		
	3	0-2 (of 49)	12-16 (of 48)	0-1 (of 33)	13-17 (of 49)		
	4	3-24 (of 49)	15-22 (of 48)	2-16 (of 33)	18-21 (of 49)		
Estimated POC-Preferred Representatives	1	2-4 (of 98)	20-26 (of 96)	15-23 (of 99)	21-27 (of 98)		
	2	4-11 (of 98)	28-36 (of 96)	27-37 (of 99)	29-36 (of 98)		
	3	1-5 (of 98)	26-33 (of 96)	24-33 (of 99)	27-33 (of 98)		
	4	5-47 (of 98)	36-42 (of 96)	30-45 (of 99)	36-41 (of 98)		
Estimated Non-Preferred Senators	1	2-6 (of 147) 2-4%	28-36 (of 144) 19-25%	15-23 (of 132) 11-18%	32-41 (of 147) 21-28%	5-9 (of 150) 3-6%	31-40 (of 150) 21-26%
	2	6-17 (of 147) 4-12%	41-54 (of 144) 29-37%	28-39 (of 132) 21-30%	44-54 (of 147) 30-37%	11-20 (of 150) 7-13%	42-57 (of 150) 28-38%
	3	1-7 (of 147) 1-5%	38-49 (of 144) 26-34%	24-35 (of 132) 19-26%	40-50 (of 147) 27-34%	4-11 (of 150) 3-7%	37-52 (of 150) 25-35%
	4	8-71 (of 147) 5-48%	51-63 (of 144) 35-44%	32-60 (of 132) 24-46%	54-62 (of 147) 37-42%	10-72 (of 150) 7-48%	53-67 (of 150) 36-45%



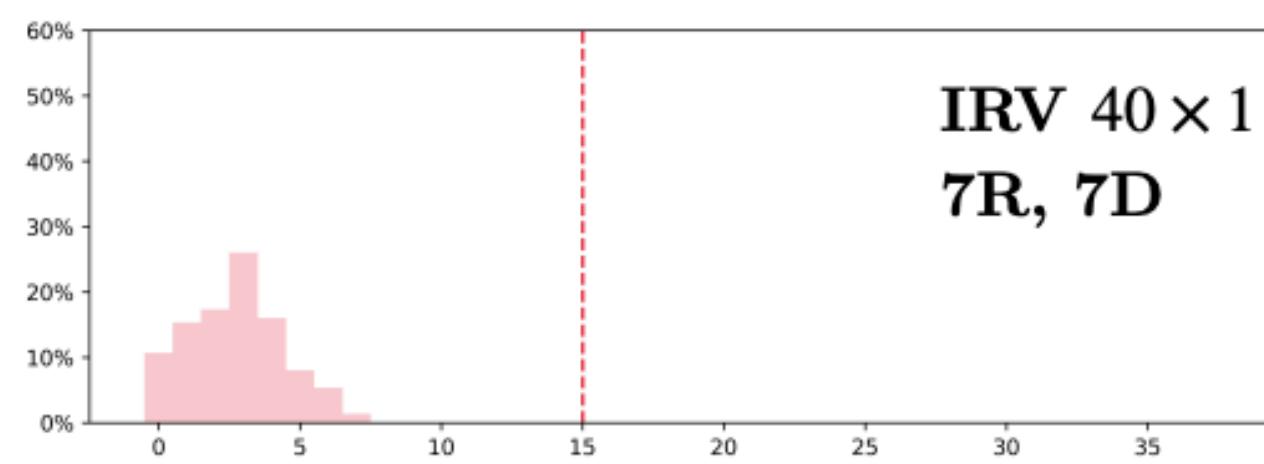
Massachusetts



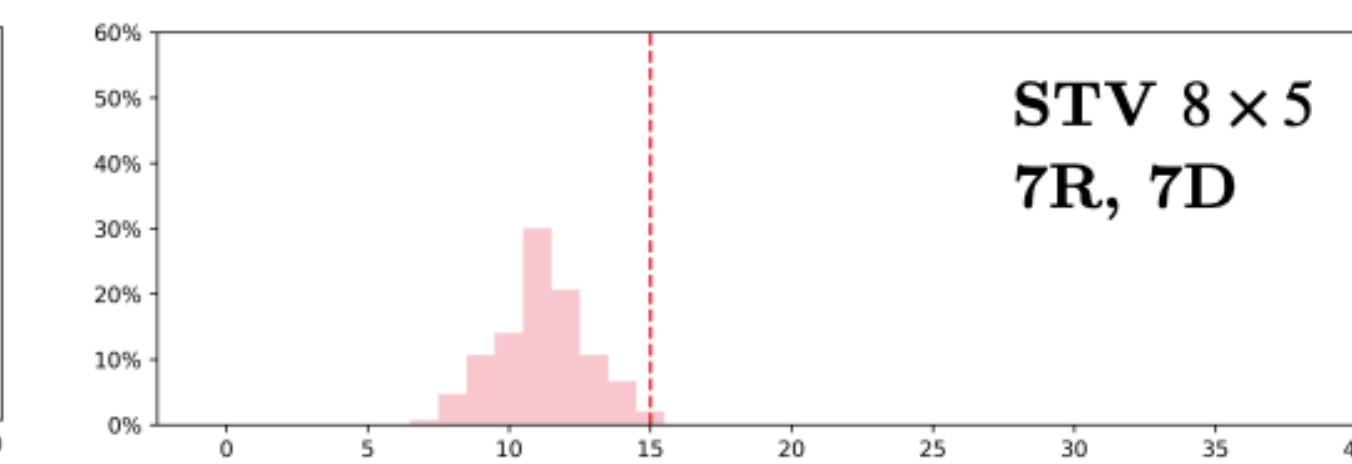
Plurality



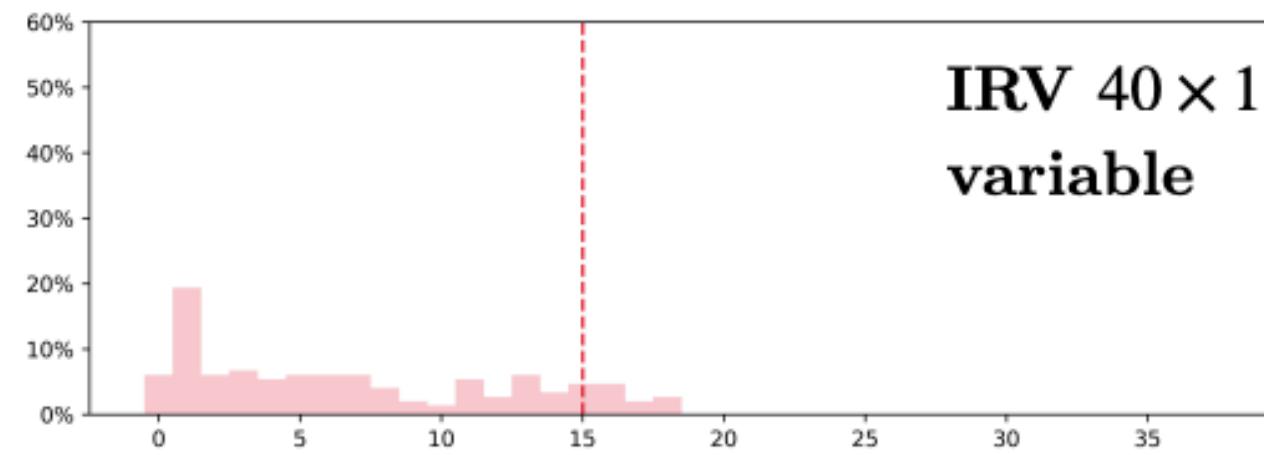
Party list



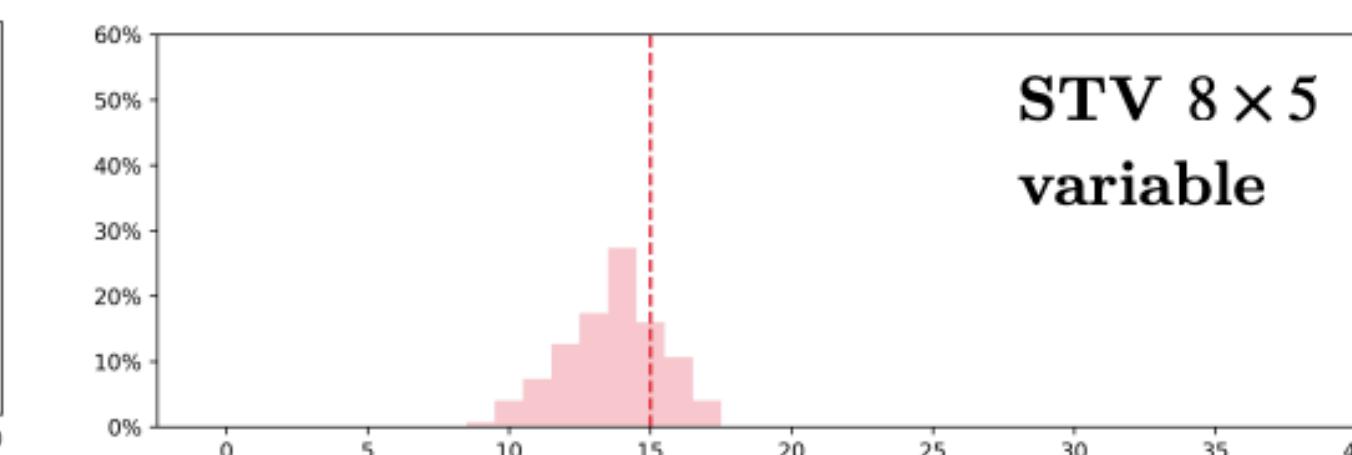
**IRV 40×1
7R, 7D**



**STV 8×5
7R, 7D**



**IRV 40×1
variable**



**STV 8×5
variable**

extras

B Appendix: Stochastic election model design

The model design is to sort by the the number of racial groups over the election threshold and the presence of a strict majority, then assign a probability distribution on the outcomes. For instance, in the magnitude-five setting, if only one racial group surpasses the $1/6$ threshold, we assign 5-0 and 4-1 election outcomes probability 60% and 40%, respectively, with respect to the first and second most prevalent racial group. To denote this efficiently, we'll divide into cases. Case 1: only one racial group exceeds threshold; Case 2: two groups exceed; Case 3: three groups exceed. Majority means that some group exceeds 50% of population; Plurality means that none does. An outcome of $a\text{-}b\text{-}c$ indicates a members of the most populous group, b of the second group, and c of the third.

50×1 – using threshold of $1/4$

Case 1 Maj	1-0, 0-1	(.98,.02)
Case 1 Plur	1-0-0, 0-1-0, 0-0-1	(.8,.18,.02)
Case 2 Maj	1-0-0, 0-1-0, 0-0-1	(.8,.18,.02)
Case 2 Plur	1-0-0, 0-1-0, 0-0-1	(.6,.3,.1)
Case 3 Plur	1-0-0, 0-1-0, 0-0-1	(.5,.3,.2)

10×5 – threshold is $1/6$

Case 1 Maj	5-0, 4-1	(.6,.4)
Case 1 Plur	5-0-0, 4-1-0, 4-0-1, 3-1-1	(.5,.4,.05,.05)
Case 2 Maj	4-1-0, 3-2-0, 2-3-0, 3-1-1, 2-2-1	(.6,.3,.05,.03,.02)
Case 2 Plur	4-1-0, 3-2-0, 2-3-0, 3-1-1, 2-2-1	(.5,.35,.1,.03,.02)
Case 3 Maj	3-1-1, 2-2-1, 2-1-2	(.6,.3,.1)
Case 3 Plur	3-1-1, 2-2-1, 2-1-2	(.5,.35,.15)
Case 4 Plur	2-1-1-1, 1-2-1-1, 1-1-2-1	(.5,.35,.15)

10×3 – threshold is $1/4$

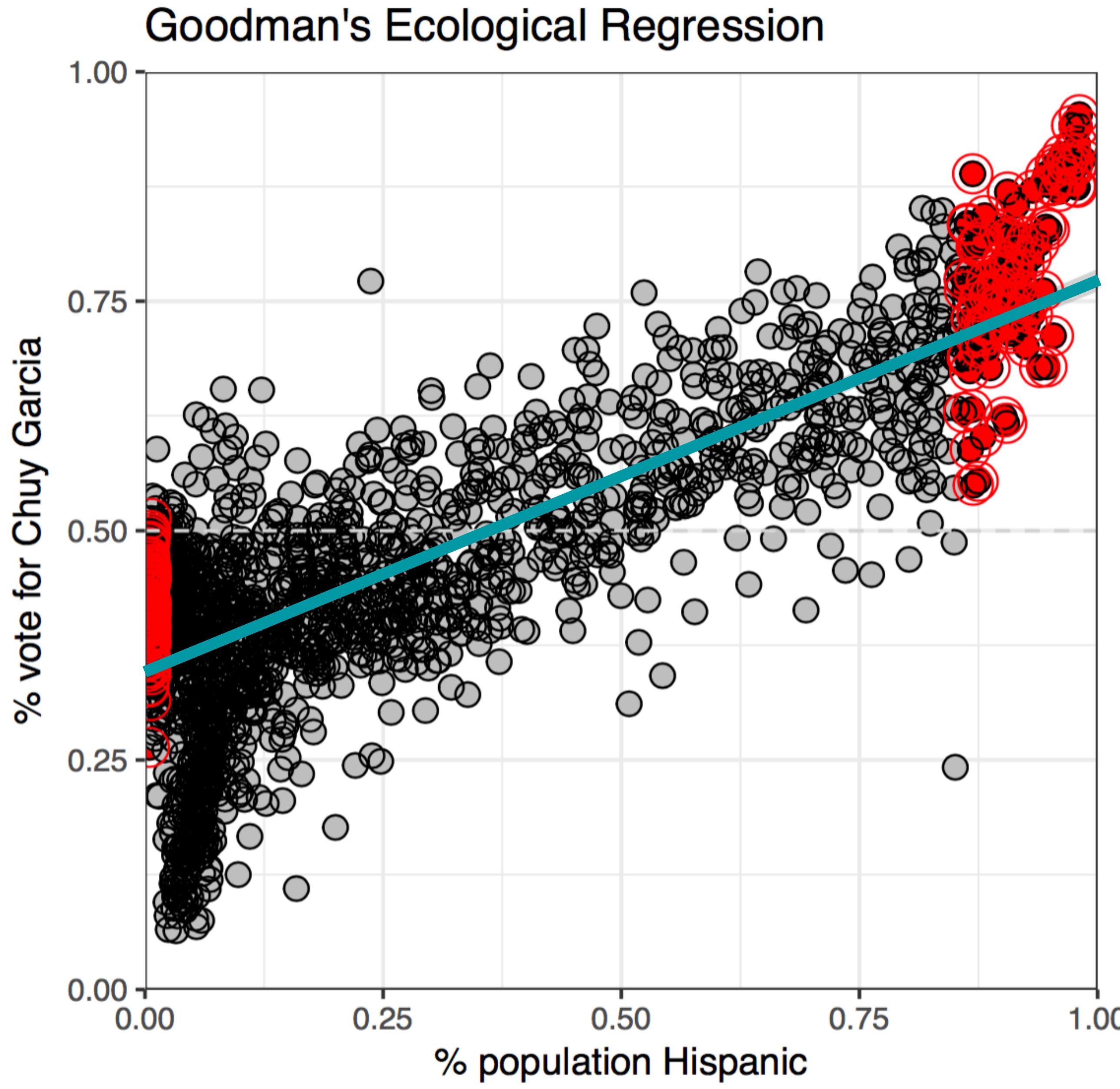
Case 1 Maj	3-0-0, 2-1-0, 2-0-1	(.90,.08,.02)
Case 1 Plur	3-0-0, 2-1-2, 2-0-1	(.6,.38,.02)
Case 2 Maj	2-1-0, 1-2-0, 3-0-0, 1-1-1	(.7,.15,.1,.05)
Case 2 Plur	2-1-0, 1-2-0, 3-0-0, 1-1-1	(.65,.25,.05,.05)
Case 3 Plur	1-1-1, 2-1-0, 3-0-0, 2-0-1, 1-2-0	(.9,.05,.02,.02,.01)

We draw a random plan from the appropriate ensemble; then for each ward, we use a $[0, 1]$ -valued random variable to decide on an electoral outcome. By summing this over the 10 or 50 wards in the plan, a slate of representatives is chosen. One set of outcomes is shown in Figure 8, and the full report of expected outcomes for all five election variants is provided in Table 1.

We created a table of probabilities based on district demographics

“Learned” from IRV elections in Oakland and Minneapolis and STV elections in Cambridge

Chicago 2015 mayoral runoff (Rahm–Chuy)



Ecological regression:
fit a line! Intercepts
with $x=0$ and $x=1$ are
estimates of vote for
non-Hisp and Hisp
voters, respectively.

“King’s EI”: instead of a scatterplot, make a **tomographic plot** where each precinct’s observed vote is consistent with a line segment’s worth of group A and group B behavior

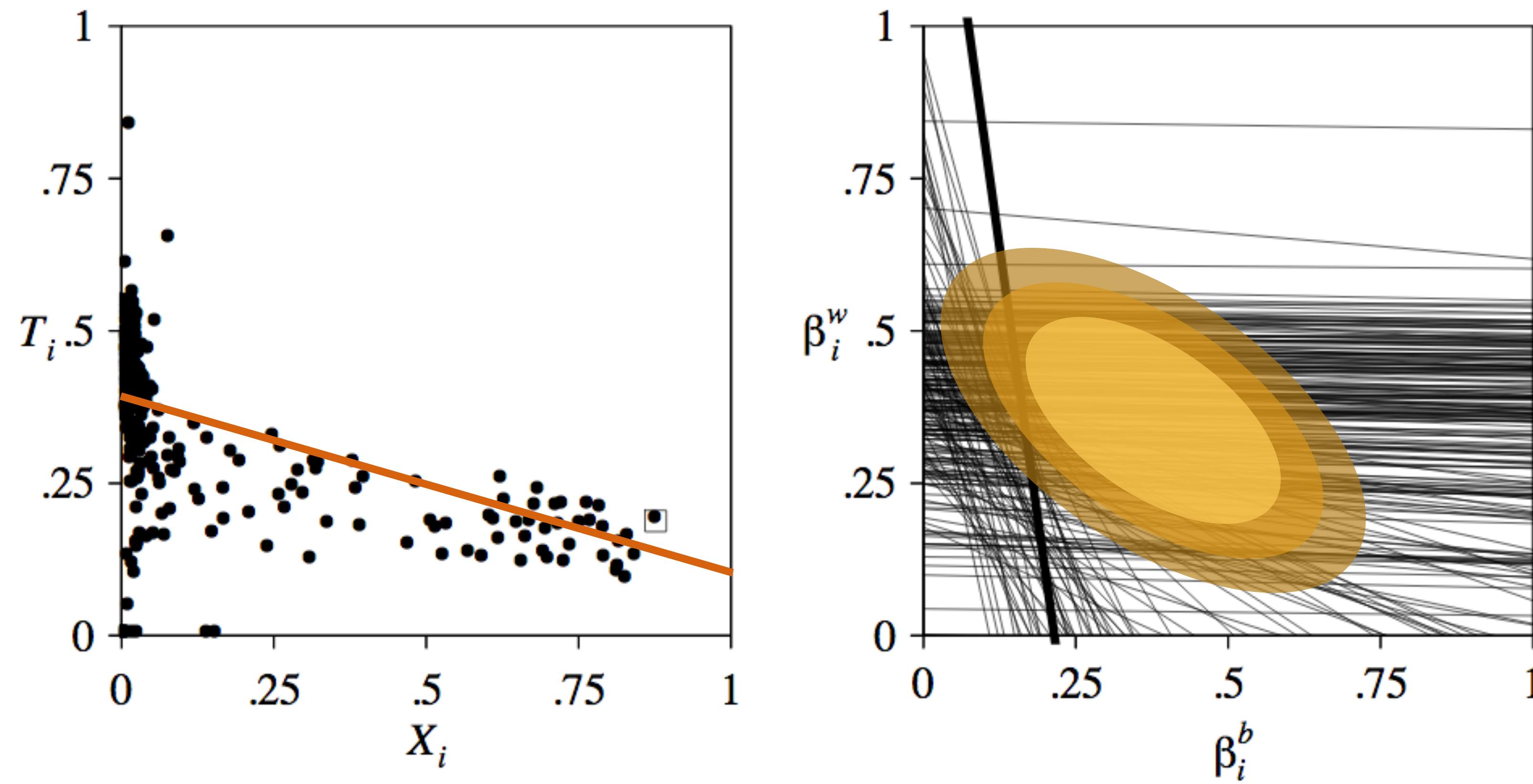


Figure 1: Two Views of the Same Data

King’s first suggestion:
if the lines all intersected, that would be a candidate for “true” voting behavior of each group. If not, use MCMC to fit a multivariate normal!

How does the city look to an ecological inference model?

