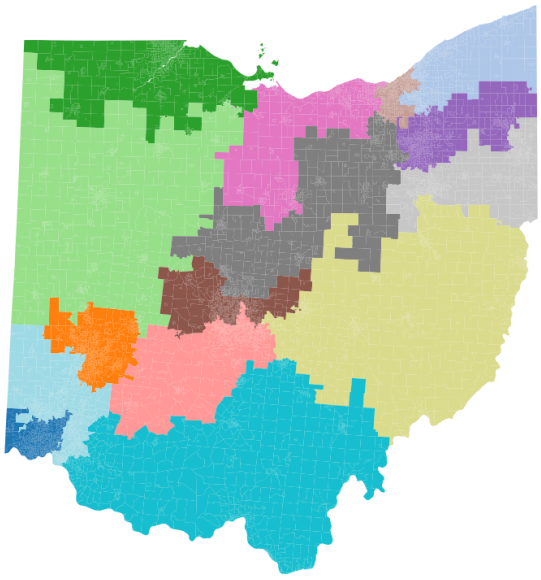
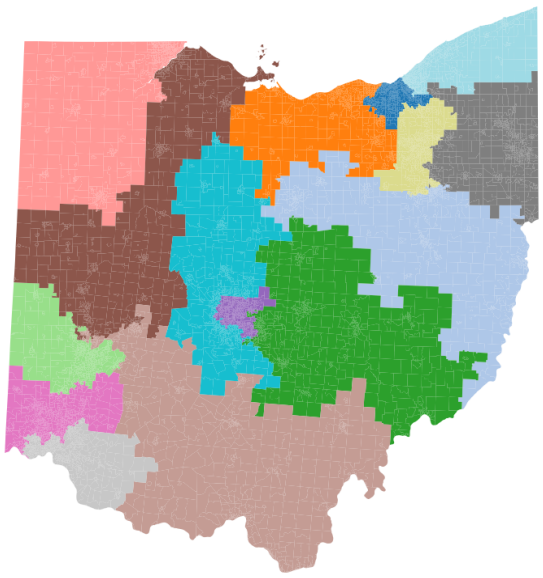
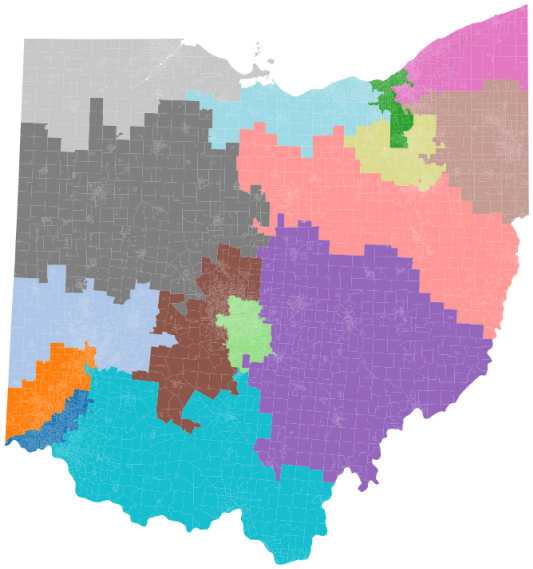
Introduction

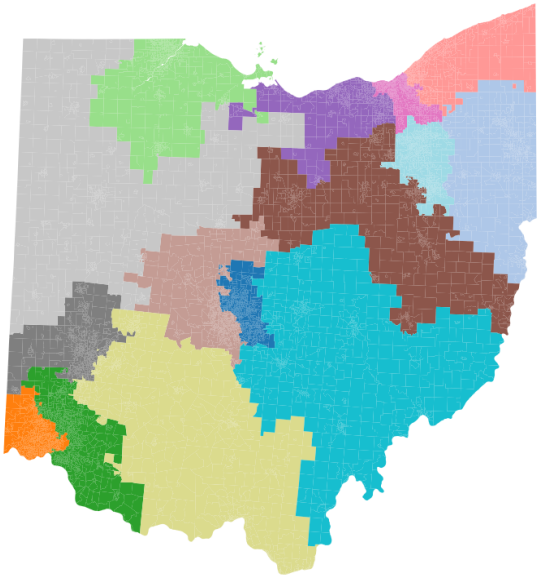
In this document, we analyze three different 15-district mock redistristricting proposals for Ohio, based on 2010 census data and 2016 election data. Our analyses hinge on the Recom algorithm, which you can read more about here.

Essentially, we claim the following: *a redistricting plan likely provides partisan advantage if the results of simulated elections on it lead to outcomes which are far away from the average outcome on a legal proposal.* For example, if an average legal plan yields 4 Democratic seats and 11 Republican seats with a small margin, a proposal that yields only 1 Democratic seat is suspicious. Recom allows us to sample from the space of all possible legal redistricting plans and run mock elections on them using pre-existing data. Each district in these samples is reasonably compact, contiguous, has 15 districts in this case for Ohio, has population deviating by at most 2%, and has two districts with at least 30% non-white population to at least attempt to approximate VRA requirements. After generating 10,000 possible plans and reducing to those meeting the specified VRA requirements, we evaluated the efficiency gap and applied existing election data to each to give expected values and standard deviations of random legal plans. The linked paper above justifies that Recom gives a reasonably good sample with fairly involved mathematics. As examples, there are several districting plans below from throughout the generated ensemble, with each of their 15 districts color-coded on the following page of this document.





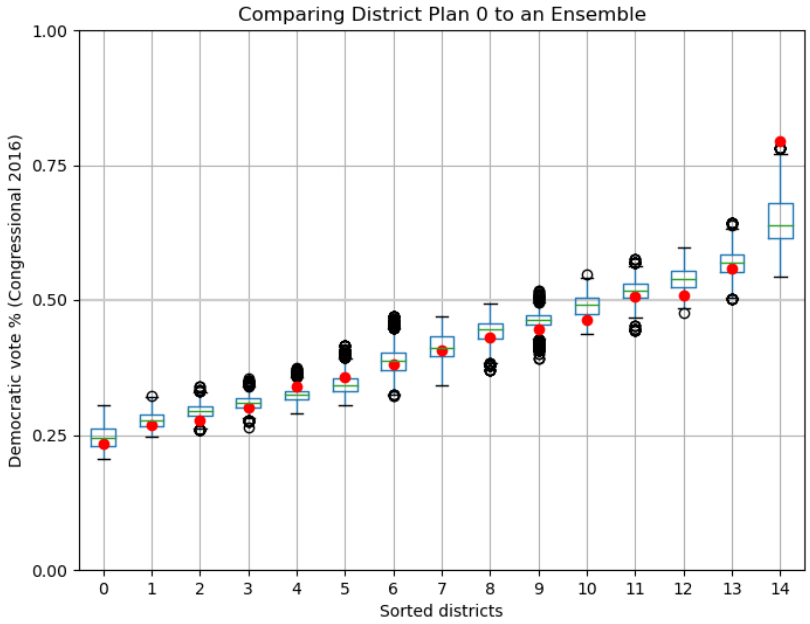




Analysis of the Proposals

Plan 0: https://districtr.org/plan/13209

After generating our representative sample of election outcomes for legal districting plans meeting our specified requirements, we are able to compare these results to the results in plans drawn by the commissioners. In the plot below, we compare the sorted percentage of democratic votes in each district in the every plan of the ensemble with the sorted percentage of democratic votes per district in plan 0. The percentages of democratic vote in plan 0 are marked by the red dots. Caution: the numbering of these districts is arbitrary in this plot and only represents the districts rank in terms of most/least democratic votes by percentage.



All of the red dots are within the error bars of this plot, except the most Democratic district in the proposal. This district has a higher percentage of Democratic vote than expected, which should not happen. Interestingly, this district is the district including Cleveland (in this case labeled district 11 in districtr) and could be classified as a packing, even though its shape does not seem gerrymandered. This is something the commissioners should be extremely careful about when drawing districts around cities. This could pose an especially difficult challenge for Detroit, a somewhat analogous Democratic bastion in Michigan.

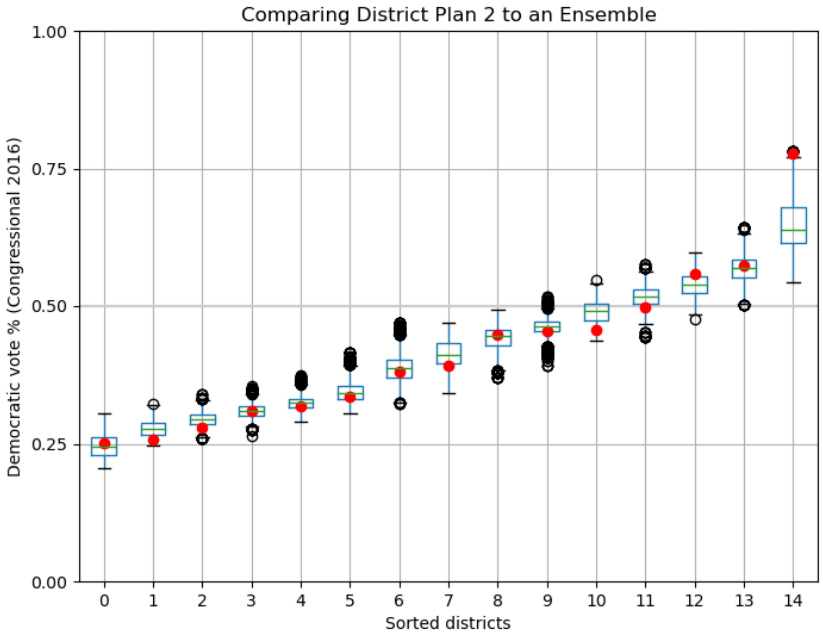
Plan 1: https://districtr.org/plan/13151

We did not include analysis of this plan, because it had a major issue. Nearly 1.6 million people were left unassigned to districts. As a result, any analyses we make for this plan would be inaccurate, since our models were not made to accommodate incomplete plans.

Plan 2: https://districtr.org/plan/13106

This plan left two precincts unassigned, “ABERDEEN VILLAGE” and “OXFORD TWP.” These were assigned to geographically adjacent existing districts—14 and 13, respectively—to accommodate analysis.

The box plot for this plan reveals the same exact issue as plan 0. The plan accidentally packs more Democratic voters than expected into the district including Cleveland (in this case district 2). If you look at the random fair maps included on the previous pages of this document, you will see that Cleveland is often the center of several districts which split it apart, allowing the Democratic voters to be dispersed amongst the surrounding districts. Again, when districts are not drawn this way, it results in a packing. While this finer attention to detail around urban centers might appear to **be** gerrymandering, it is instead the result of urban centers having far more precincts per area and demanding more detailed redistricting.



Partisan Fairness and Mock Election Results

Now we analyze the results of mock elections in each of these districting plans using 2016 election data. Essentially, we fix some election and then assume each precinct votes for the Republican/Democratic candidate in that district with the exact same turnout. After tallying the votes over all precincts in each district, we can conclude the partisan outcomes. While the U.S. House election data is the most representative in this case, we include other available election data for completeness (Presidential, U.S. Senate, State Senate, State House).

SEATS & PERCENTAGES			
		Democratic vs Republican Seats in proposal (Democratic %)	Mean Democratic Seats in Ensemble ± Standard Deviation
Plan 0	US House	4 vs. 11 (26.67%)	4.122 ± 0.7506
	US Senate	2 vs. 13 (13.33%)	2.37 ± 0.6155
	US Presidential	5 vs. 10 (33.33%)	5.026 ± 0.9195
	State House	4 vs. 11 (26.67%)	4.084 ± 0.6326
	State Senate	1 vs. 14 (6.67%)	1.724 ± 0.5753
Plan 2	US House	3 vs. 12 (20.00%)	4.122 ± 0.7506
	US Senate	2 vs. 13 (13.33%)	2.37 ± 0.6155
	US Presidential	6 vs 9 (40.00%)	5.026 ± 0.9195
	State House	4 vs 11 (26.67%)	4.084 ± 0.6326
	State Senate	1 vs 14 (13.33%)	1.724 ±0.5753

In general, the partisan outcomes of these proposals are not especially unlikely. The outcomes using State Senate results are on the low end for both proposals and the U.S. House results are somewhat low for the second proposal. However, neither proposal leads to outcomes which are sufficiently unlikely to cause concern.

Efficiency Gap

The efficiency gap is defined as the number of "wasted" Republican votes minus the number of "wasted" democratic votes divided by the number of votes cast for both parties in total. A vote is considered wasted in this case if it is extra after giving a party a majority or if it is cast for a losing candidate. For example, if a Democratic candidate wins 80% of the vote, 30% of those votes are considered wasted as are the votes for the losing Republican opposition candidate. In the below table, a negative value indicates an advantage for the Republican party.

The efficiency gap is also defined in detail in this paper: https://arxiv.org/abs/1801.02064

EFFICIENCY GAP			
		Efficiency Gap	Avg Efficiency Gap
Plan 0	US House	-0.07076	-0.06148 ± 0.05062
	US Senate	-0.1538	-0.1222 ± 0.04248
	US Presidential	-0.06775	-0.07142 ± 0.0635
	State House	-0.05142	-0.0488 ± 0.0435
	State Senate	-0.08221	-0.05148 ± 0.0391
Plan 2	US House	-0.1436	-0.06148 ± 0.05062
	US Senate	-0.1537	-0.1222 ± 0.04248
	US Presidential	-0.007858	-0.07142 ± 0.0635
	State House	-0.05645	-0.0488 ± 0.0435
	State Senate	-0.1123	-0.05148 ± 0.0391

The efficiency gap is well within the expected range in each case, except for the State Senate and U.S. House results for the second plan. In these instances, the efficiency gap is far enough in favor of the Republican party to suggest that this plan is at least favoring Republicans more than average. Nonetheless, since the values are within two standard deviations of the expected efficiency gap, they are not cause for significant concern.

We provide two additional metrics of partisan fairness below. Their definitions are provided and they further explained here, but we do not include them in our analysis.

The partisan bias is defined as the number of districts with above mean vote share by the Democratic party divided by the total number of districts, minus 1/2.

PARTISAN BIAS			
		Partisan Bias	Avg Partisan Bias
Plan 0	US House	-0.03333	-0.007279 ± 0.06117
	US Senate	-0.03333	-0.01926 ± 0.05672
	US Presidential	-0.03333	-0.0439 ± 0.05649
	State House	0.03333	-0.02746 ± 0.05995
	State Senate	0.1	-0.009381 ± 0.0642
Plan 2	US House	-0.03333	-0.007279 ± 0.06117
	US Senate	-0.03333	-0.01926 ± 0.05672
	US Presidential	-0.03333	-0.0439 ± 0.05649
	State House	0.03333	-0.02746 ± 0.05995
	State Senate	-0.03333	-0.009381 ± 0.0642

Partisan Gini measures the difference in the seats/votes curves for the two parties.

PARTISAN GINI			
		Partisan Gini	Avg Partisan Gini
Plan 0	US House	0.05127	0.03188 ± 0.01215
	US Senate	0.04542	0.03091 ± 0.01175
	US Presidential	0.04761	0.02987 ± 0.01182
	State House	0.05344	0.0354 ± 0.01254
	State Senate	0.03345	0.03047 ± 0.01016
Plan 2	US House	0.05003	0.03188 ± 0.01215
	US Senate	0.04769	0.03091 ± 0.01175
	US Presidential	0.05628	0.02987 ± 0.01182
	State House	0.05354	0.0354 ± 0.01254
	State Senate	0.02415	0.03047 ± 0.01016

These are the functions used to calculate the metrics:
https://gerrychain.readthedocs.io/en/latest/api.html#module-gerrychain.metrics

This analysis was done as part of work done by the University of Michigan Laboratory of Geometry Gerrymandering and Visualization group. This project is advised by Samuel Hansen and Tim Ryan with students Henry Fleischmann, Seth Greenfield, Christina Jiang, and Aelita Klausmeier.