

An Ensemble Analysis: How Gerrymandering Changed the 2024 Election

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In the 2024 U.S. House of Representatives Election, the Republicans won 220 seats and the Democrats won 215 seats, securing the House for the Republicans. Currently, there are nine states with congressional districting plans in litigation, meaning current court cases are arguing that the maps are a racial or partisan gerrymander. Thus, we were curious if the election could have had a different outcome if these nine states had fair maps. We conducted an analysis to determine if the impact of these disputed districts could have changed control of Congress.

To do this, we used statewide elections for the Governor, U.S. Senator, and U.S. President to gauge voters' partisanship. To ensure that our process was similar across all nine states, we chose not to use U.S. House of Representative election data. This is because candidates tend to vary in quality and views across each district, meaning that a voter's choices in one election might not necessarily reflect their overall preference in this election. Instead, a statewide election with more consistent candidates allows us to understand preferences across the entire population.

Additionally, we focused only on Democratic and Republican votes for this particular election. In no state was an independent candidate selected, so we did not feel it necessary to include that data in our analysis. After finding our data on election results and Census data, we downloaded shapefiles for the current congressional districting maps. We then compared each district with the Democratic and Republican votes to determine how many seats each party won in that state. Finally, we created a Markov Chain from various starting points (and running for various lengths) to find the most likely distribution of seats for each party. We concluded that this outcome would be the most likely outcome for each state if they had a 'fair' map.

In this report, we will first detail our process and conclusions for each of the nine states: Georgia, Texas, Utah, South Carolina, North Carolina, Florida, Louisiana, Arkansas, and Alabama. For each state, we will provide a brief background of the litigation, our analysis of the Markov chain, an argument that the Markov Chain has reached its stationary distribution, some limitations of the data, and how a "fair" map would have changed the outcome of the 2024 US House of Representatives election.

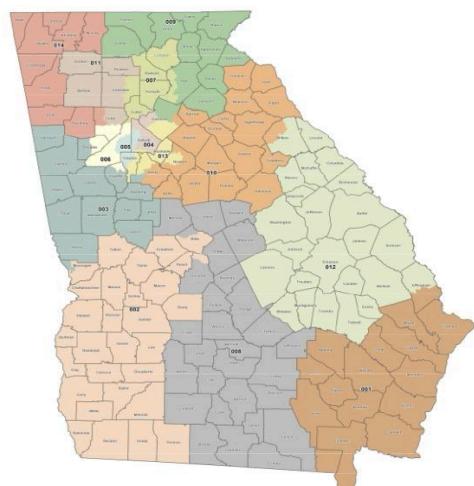
Georgia

Background

Georgia passed their congressional district map in 2021. However, in December of 2021, it was challenged as an unconstitutional partisan and racial gerrymandering, and in October, 2023, the court found the map in violation of the Voting Rights Act. They ordered the state to put into effect a new map by the end of December which would then be used in the 2024 election. The 2023 plan was a placeholder to address some of the problems with the 2021 plan so that the 2024 election would have a less problematic plan. While the court approved the new map, plaintiffs are still arguing that the Republican proposed 2023 map is unfair.



2021 Congressional Districting Map



2023 Congressional Districting Map

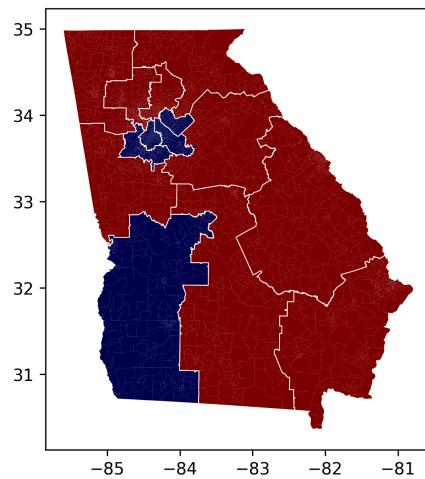
Data

Since Georgia had two congressional districting plans since the 2020 census, I wanted to use both of them and analyze how gerrymandered they were compared to the Markov chain from a random districting plan. I found shapefiles for both the 2021 and 2023 congressional districts from the Proposed Plans tab on the [Georgia General Assembly website](#).

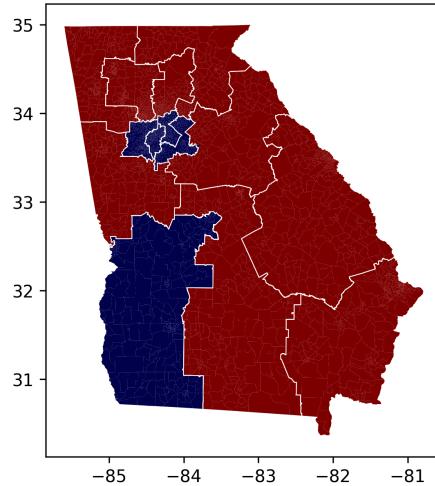
I used the Georgia 2022 U.S. Senate runoff election results from [Redistricting Data Hub](#). Since results did not include precinct geometries, I joined the election data with the shapefile in the folder *ga_2022_gen_st_prec* from the [2022 General Senate Results](#) to get the precinct geometries. Then, I joined race demographics at the block level from the [2020 Census Data](#) which I joined with block shapefile data from [Tiger/Shapefiles website](#), which I then aggregated up to the precinct level to then combine with the voting data. This provided me with a GeoDataFrame with precinct voting and demographic data for Georgia which I could use to run and analyze my Markov Chain.

Analysis

To analyze partisanship in Georgia, we used the 2022 U.S. Senate Runoff Election results between Democrat Raphael Warnock and Republican Herschel Junior Walker. Using both the 2021 and 2023 plan and the votes from the 2022 Senate election, Democratic House candidates would have won in 5 districts while Republican candidates would have won in 9 districts. Furthermore, the 2021 plan had 3 Black majority districts and the 2023 plan had 4 Black majority districts.

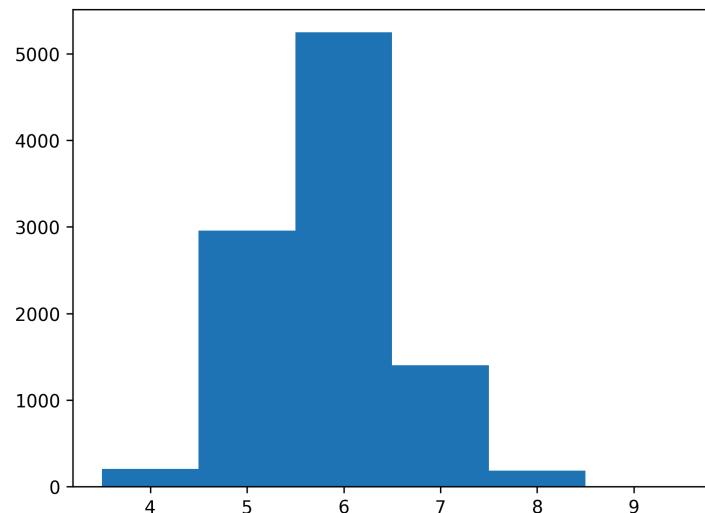


Original 2021 Plan - Democratic/Republican Districts

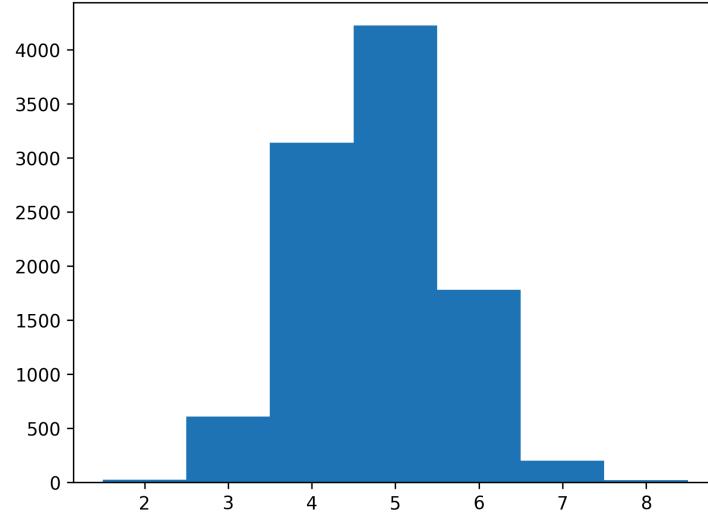


2023 Plan - Democratic/Republican Districts

Using a random walk starting at a random initial districting plan, we ran our chain for 10,000 steps to explore the state space of Georgia to find what districting plans were most likely. We found that 6 Democratic majority districts and 5 Black majority districts were most likely, however 5 Black majority districts were pretty close. Thus, our random walk seems to suggest that both plans were a racial and partisan gerrymander.



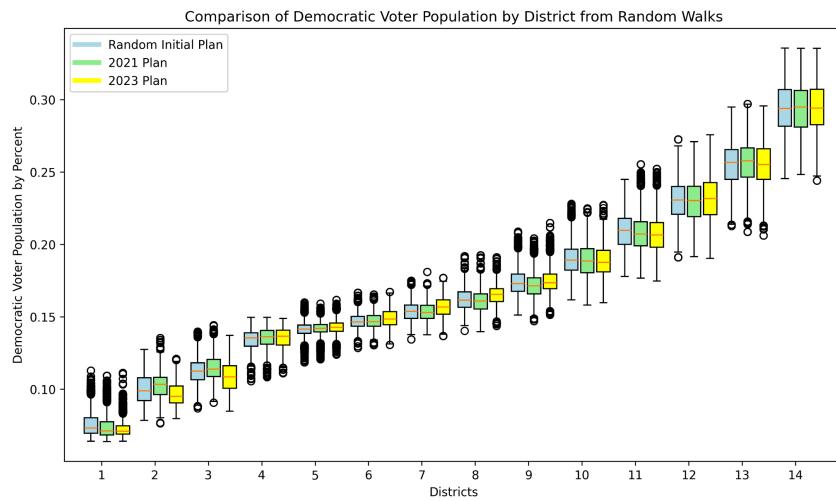
Most Likely # of Democratic-Majority Districts in Georgia, from a Random Plan



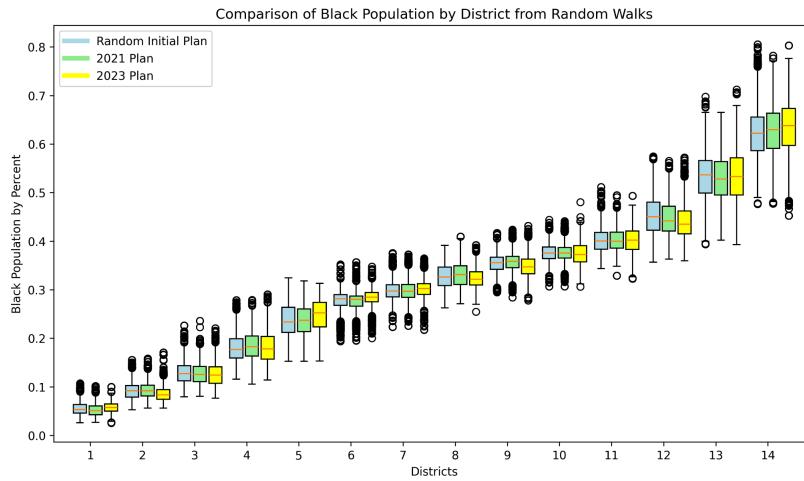
Most Likely # of Black-Majority Districts in Georgia, from a Random Plan

Mixing Time

To ensure we ran our random walk for long enough, we compared the previous results to the distributions of results from random walk starting at both the 2021 and the 2023 plan. Below are box and whisker plots showing the outcome.



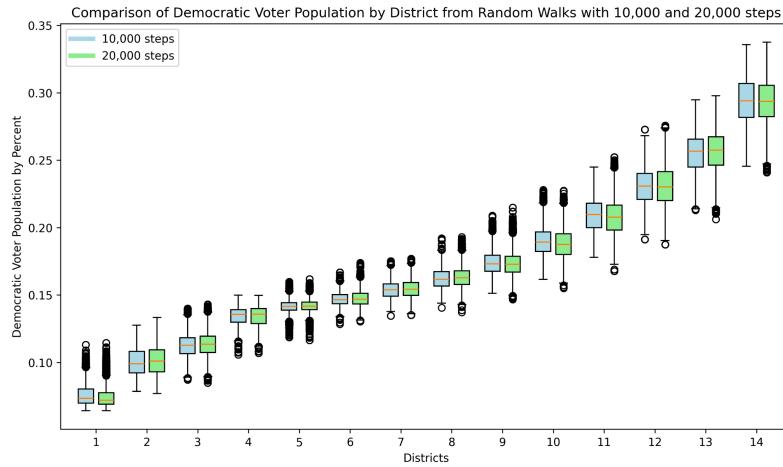
Distribution of Democratic Voter Population by Districts across Random Walks



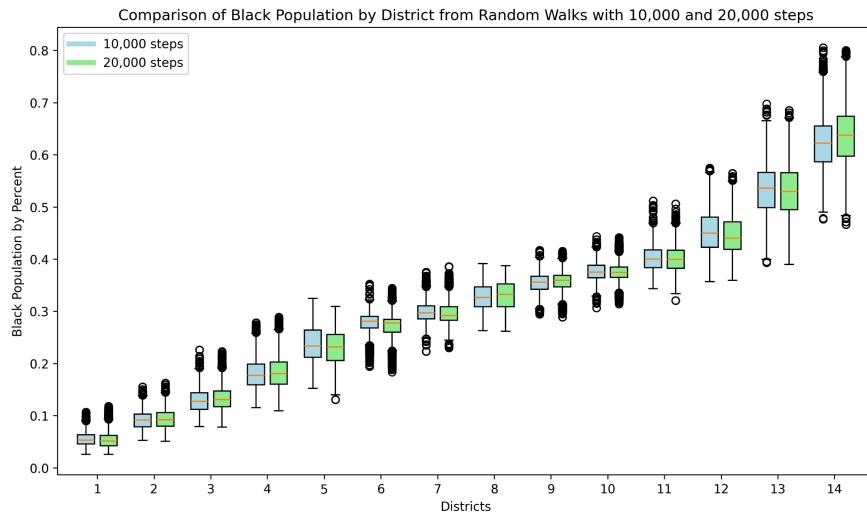
Distribution of Black Population by Districts across Random Walks

Since the distribution for the districts across all three random walks is very similar, we argued that running our walk for 10,000 steps was sufficiently long.

We also compared the results from our random walk for 10,000 steps to a random walk for 20,000 steps that started at the same random initial districting plan. The distributions for both the 10,000 step and 20,000 step random walks were similar, suggesting that running our random walk for more steps would not affect the outcome.



Distribution of Democratic Voter Population by Districts across Random Walks



Distribution of Black Population by Districts across Random Walks

Limitations

One limitation in the analysis of Georgia is that we used voting data results from 2022 to predict what party voters would vote for in 2024. We are assuming voters' party preference would stay the same and are not taking into account how time or candidates could affect how a voter votes.

Furthermore, although our ensemble suggests that there should be 6 Democratic majority districts in Georgia, our ensemble's second most likely scenario was that Georgia would have 5 Democratic districts. Therefore, we cannot claim outright that either map was a partisan gerrymander. Similarly, while the ensemble suggested that 5 Black majority districts was most likely, it did include 3 and 4 Black majority districts as possibilities. However, our ensemble does not have all the information.

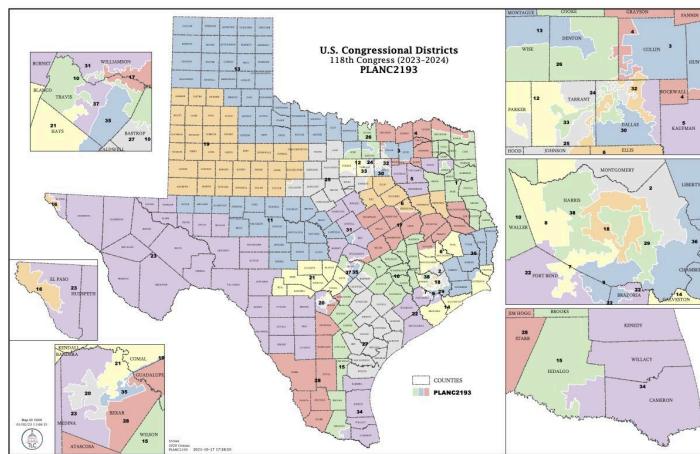
Conclusion

The ensemble analysis suggests that both districting plans in Georgia were partisan and racial gerrymanders, however we cannot conclude that as definitive. But for the purposes of our analysis, we will conclude that based on the ensemble analysis, in 2024, Georgia should have 6 Democratic districts (instead of the 5 districts that elected Democratic Representatives in 2024) as well as 5 Black majority districts.

Texas

Background

Following the 2020 census, Texas passed their new congressional districting plan on October 25, 2021. However, it was quickly brought to court for numerous litigation claims that it was a racial gerrymander against Black and Latino voters.



2021 Congressional Districting Plan

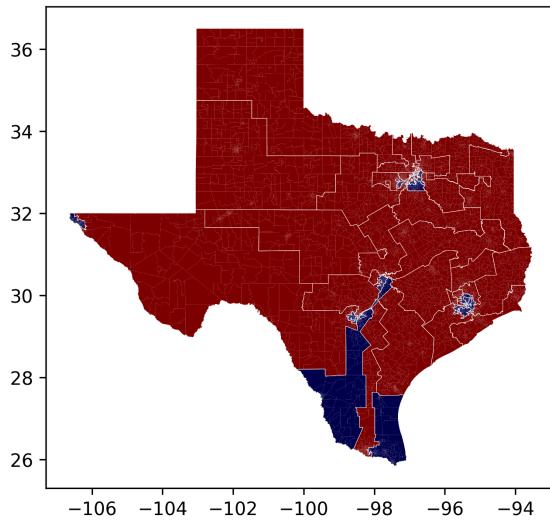
Data

Since Texas has only had one districting plan put into place following the 2020 census, I wanted to compare that one to a Markov chain from a random districting plan. I used the congressional map shapefile from the [Capitol Data Portal](#) for the Texas Legislative Council.

I used the 2020 U.S. Presidential Election results from the [University of Florida Election Lab](#). Then, I joined race demographics at the block level from the 2020 Census Data which I joined with block shapefile data from [Tiger/Shapefiles website](#), which I then aggregated up to the precinct level to then combine with the voting data. This provided me with a GeoDataFrame with precinct voting and demographic data for Texas which I could use to run and analyze my Markov Chain.

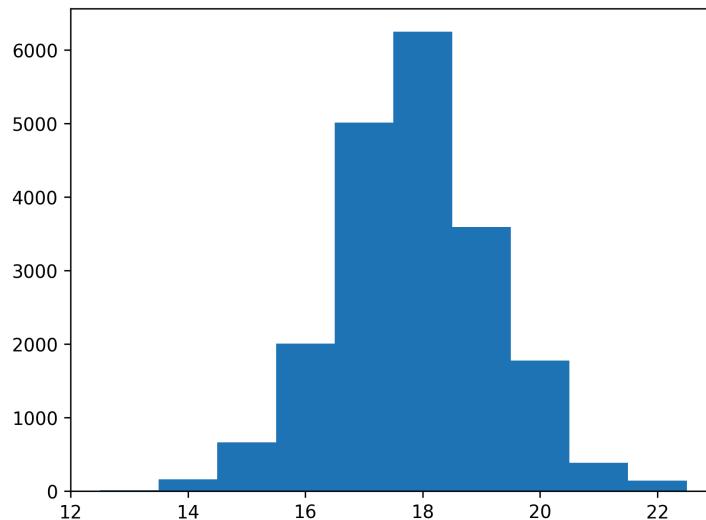
Analysis

To analyze partisanship in Texas, we used the 2020 U.S. Presidential Election results between Democrat Joe Biden and Republican Donald Trump. Using the 2021 plan and the votes from the 2020 Presidential election, Democratic House candidates would have won in 13 districts while Republican candidates would have won in 25 districts. Furthermore, the 2021 plan had 1 Black majority district and 14 Hispanic majority districts.

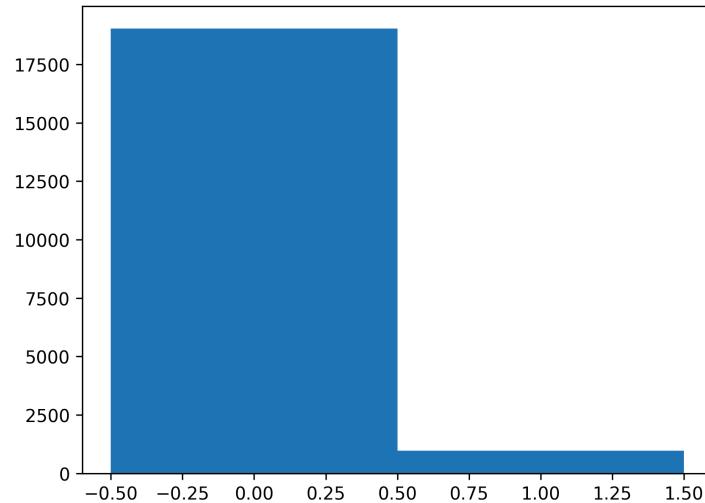


Original 2021 Plan - Democratic/Republican Districts

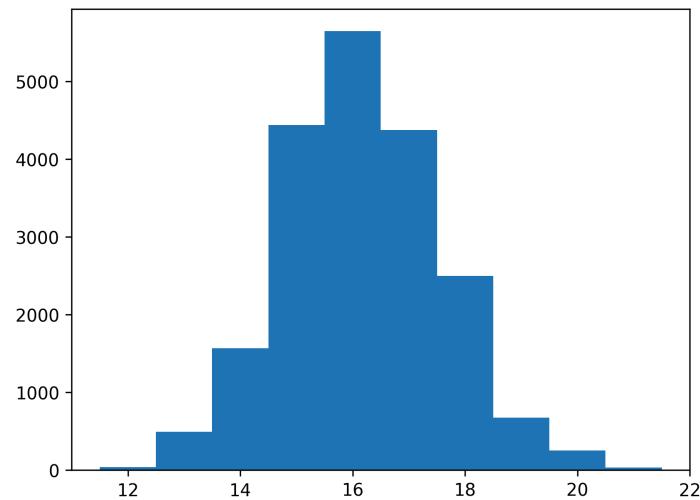
Using a random walk starting at a random initial districting plan, we ran our chain for 20,000 steps to explore the state space of Texas to find what districting plans were most likely. We found that 18 Democratic majority districts, 0 Black majority districts, and 16 Hispanic majority districts were most likely. Thus, our random walk seems to suggest that both plans were a racial gerrymander against Hispanic and Latino voters and a partisan gerrymander.



Most Likely # of Democratic-Majority Districts in Texas, from a Random Plan



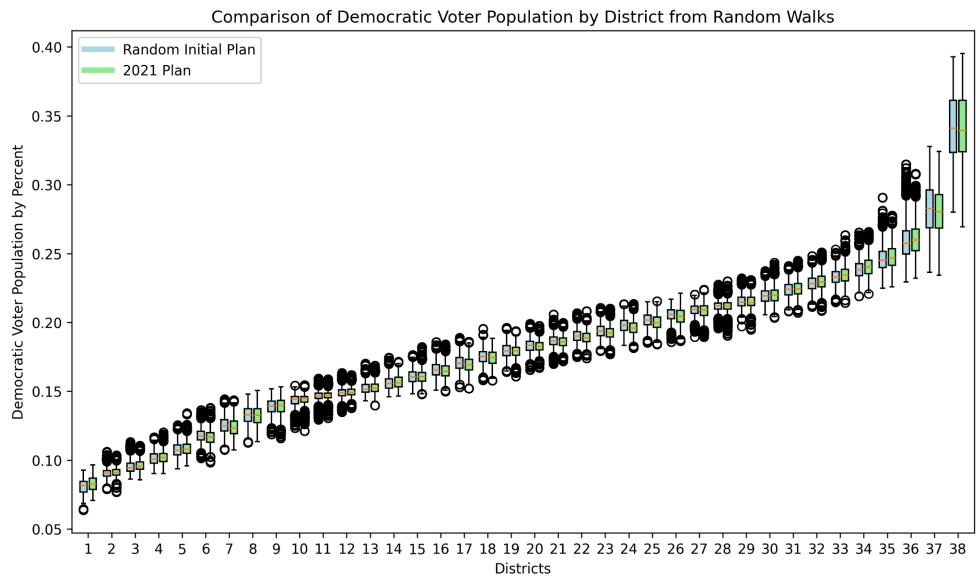
Most Likely # of Black-Majority Districts in Texas, from a Random Plan



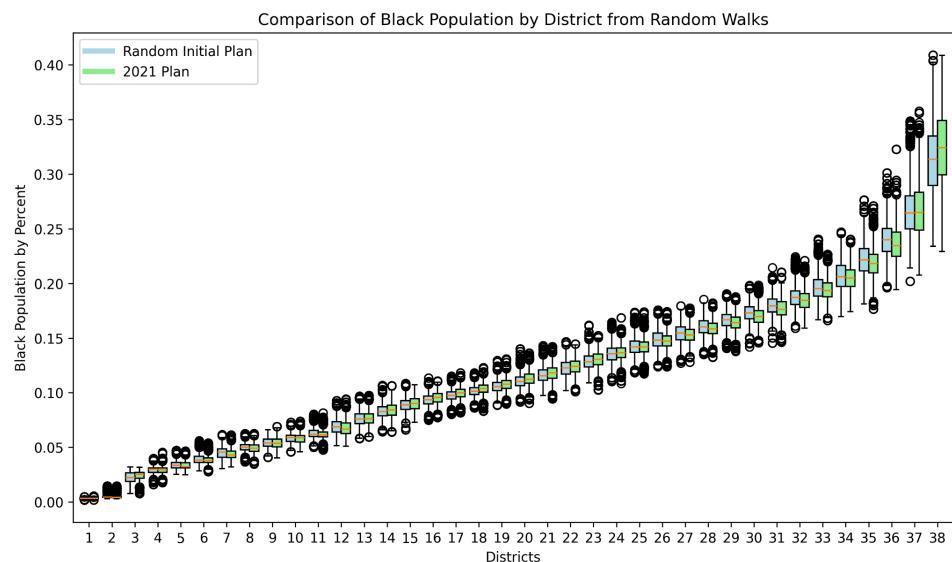
Most Likely # of Hispanic-Majority Districts in Texas, from a Random Plan

Mixing Time

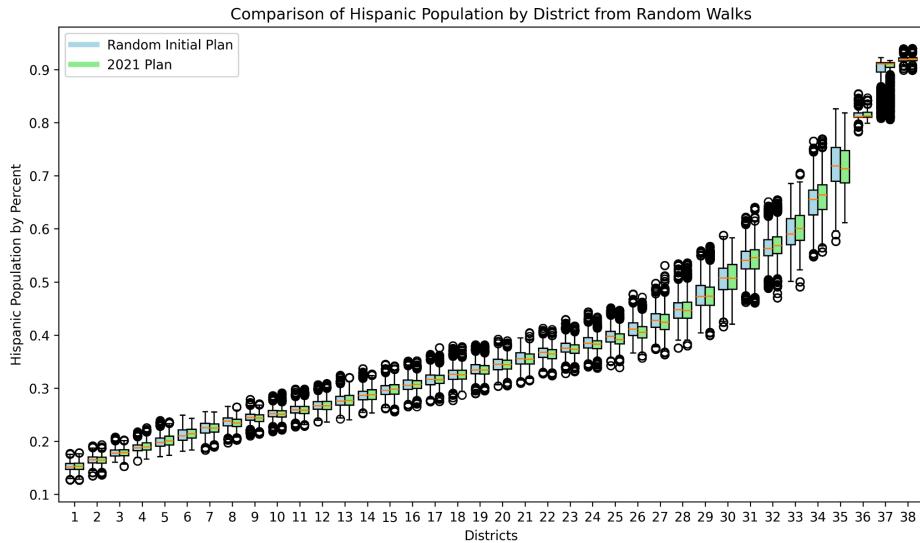
To ensure we ran our random walk for long enough, we compared the previous results to the distributions of results from random walk starting at the 2021. Below are box and whisker plots showing the outcome.



Distribution of Democratic Voter Population by Districts across Random Walks



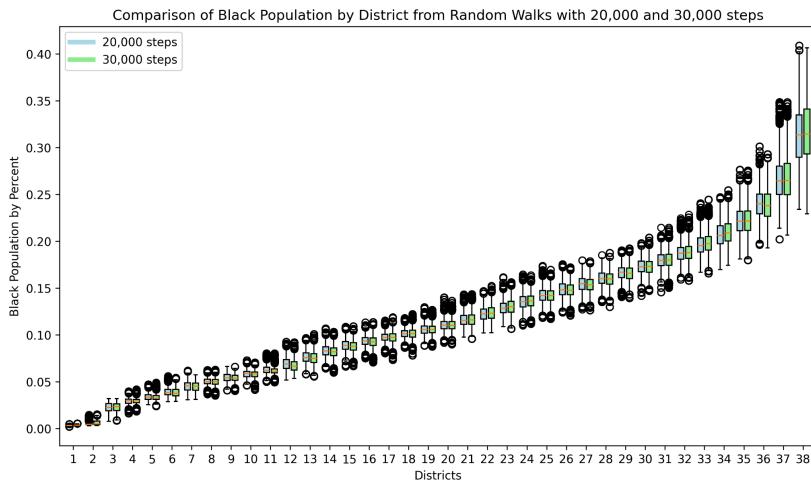
Distribution of Black Population by Districts across Random Walks



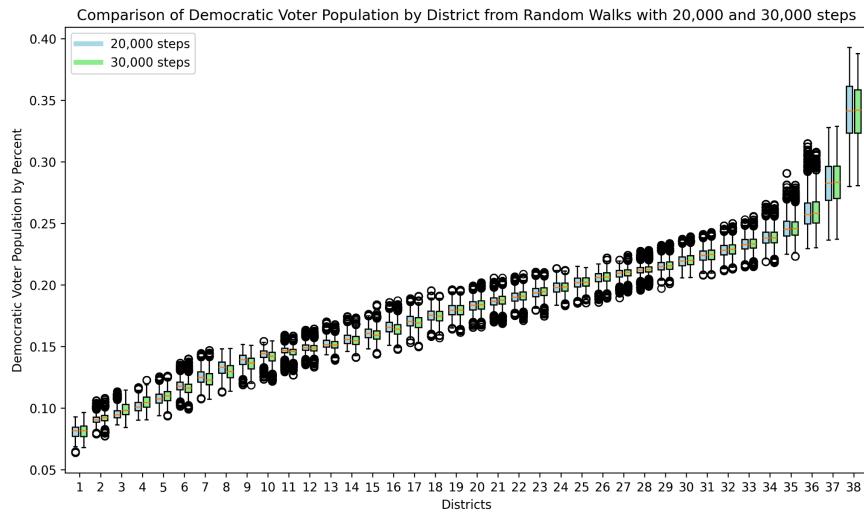
Distribution of Hispanic Population by Districts across Random Walks

Since Texas has so many districts, it is a bit challenging to read the plots. However, we can see the two random walks have similar distributions though not the same or as close as we saw for Georgia. Thus, I think that running our walk for 20,000 steps was not sufficiently long.

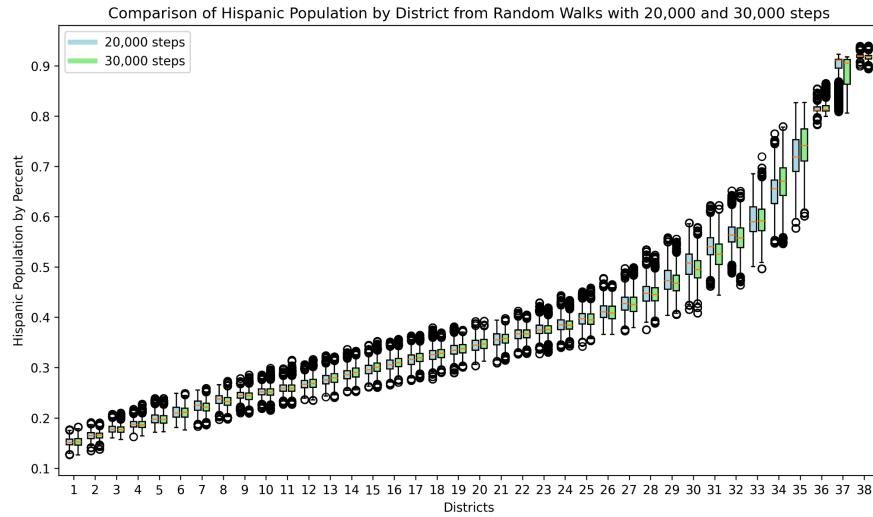
Moreover, we also compared the results from our random walk for 20,000 steps to a random walk for 30,000 steps that started at the same random initial districting plan. The distributions for the 30,000 step random walk were a bit different from the distribution of the 20,000, corroborating the belief that the random walk had not yet converged at 20,000 steps and that we should have run it for longer.



Distribution of Democratic Voter Population by Districts across Random Walks



Distribution of Black Population by Districts across Random Walks



Distribution of Hispanic Population by Districts across Random Walks

Limitations

One limitation in our predictions was that we used data from 2020 to predict voter party preference four years later. While there was no U.S. Senate election in 2022, there were both elections for Governor and Attorney General, which are statewide elections. However, we decided not to use the 2022 Attorney General race between Republican Ken Paxton and Democrat Rochelle Garza because Paxton has faced security fraud charges and is being investigated by the FBI. This election did not seem like a normal one, and we wanted more conventional election candidates to best predict how voters would vote. We were going to use the results for the 2022 Governor election, but we were only able to find the results by VTDs or by blocks. The VTDs didn't join nicely to the 2020 census VTDs because they changed and the

block data set took too long to load, which is why we had to resort to the 2020 Presidential Election results.

Another effect on our results could be from not running the random walk for long enough. When I ran the random walk for 10,000 steps, it was clear it had not explored all the state space as the distributions for the two different starting points (a random districting plan and the 2021 one) were different. However, even when we ran from 20,000 steps, we still see some difference between the distributions suggesting that we need to run our random walk for 30,000 or more steps to get a reasonable distribution of results.

This could have affected the distribution of Democratic, Black, and Hispanic majority districts our ensemble believes in most likely. The ensemble states that 18 Democratic majority districts, 0 Black majority districts, and 16 Hispanic majority districts were most likely. However there were plans in the distribution that had 13 Democratic districts, 1 Black majority district, and 14 Hispanic majority districts. Another reason that we cannot take the most likely outcome as the truth is that our ensemble does not have all the information. For those reasons, we cannot definitively claim that the 2021 plan was a gerrymander.

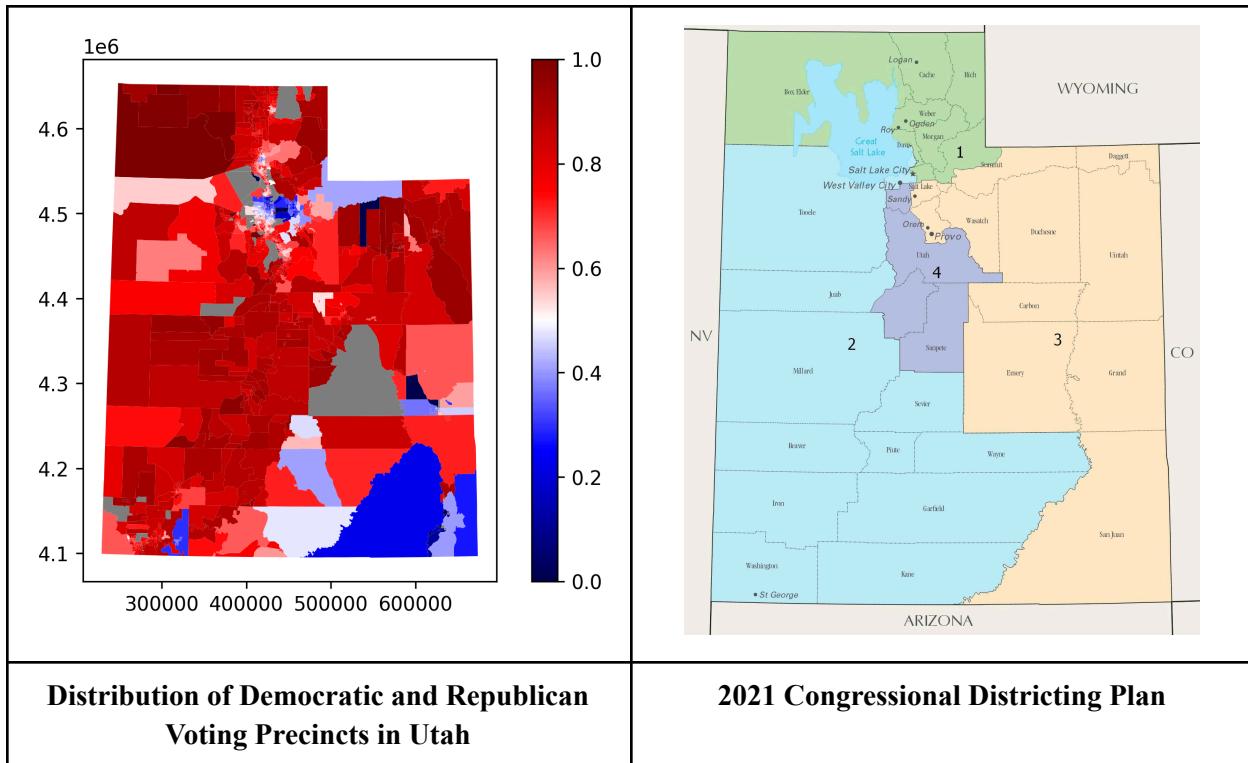
Conclusions

Our ensemble analysis suggests that the districting plan in Texas was gerrymandered, however we cannot conclude that as definitive. But for the purposes of our analysis, we will conclude that based on the ensemble analysis, in 2024, Texas should have had 18 Democratic districts (instead of the 13 districts that elected Democratic Representatives in 2024) as well as 0 Black majority districts and 14 Hispanic majority districts.

Utah

Background

In November of 2021, Utah passed their congressional districting plan following the 2020 census. In March of 2022, the map was challenged as a partisan gerrymander against Democrats. The challenge is based on the claim that Republican legislators cracked Salt Lake County, a democratic leaning county. In the graphic representing the distribution of Democratic and Republican Voting Precincts, we can see that there is a blue clump of voters representing Democratic voters near the top, which is Salt Lake County. However, in the second graphic, we see that this county is split by all four districts.



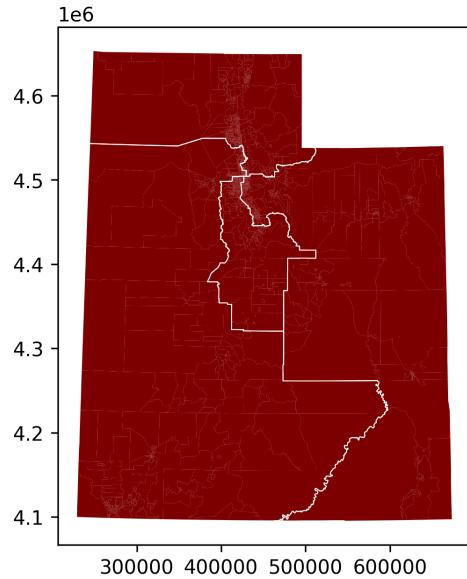
Data

The shapefile for the 2021 congressional districts was labeled “CONGRESS ENROLLED HB2004” under the Congress Tab on the [Utah Legislative Redistricting Committee website](#).

I used the 2020 U.S. Presidential Election results from the [University of Florida Election Lab](#). Then, I joined race demographics at the block level from the 2020 Census Data which I joined with block shapefile data from [Tiger/Shapefiles website](#), which I then aggregated up to the precinct level to then combine with the voting data. This provided me with a GeoDataFrame with precinct voting and demographic data for Utah which I could use to run and analyze my Markov Chain.

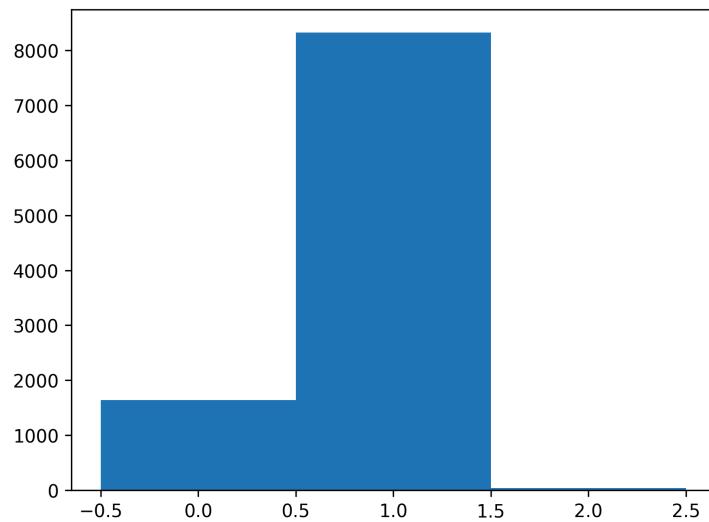
Analysis

To analyze partisanship in Utah, we used the 2020 U.S. Presidential Election results between Democrat Joe Biden and Republican Donald Trump. Using the 2021 plan and the votes from the 2020 Presidential election, Democratic House candidates would have won in 0 districts while Republican candidates would have won in all 4 districts.



Original 2021 Plan - Democratic/Republican Districts

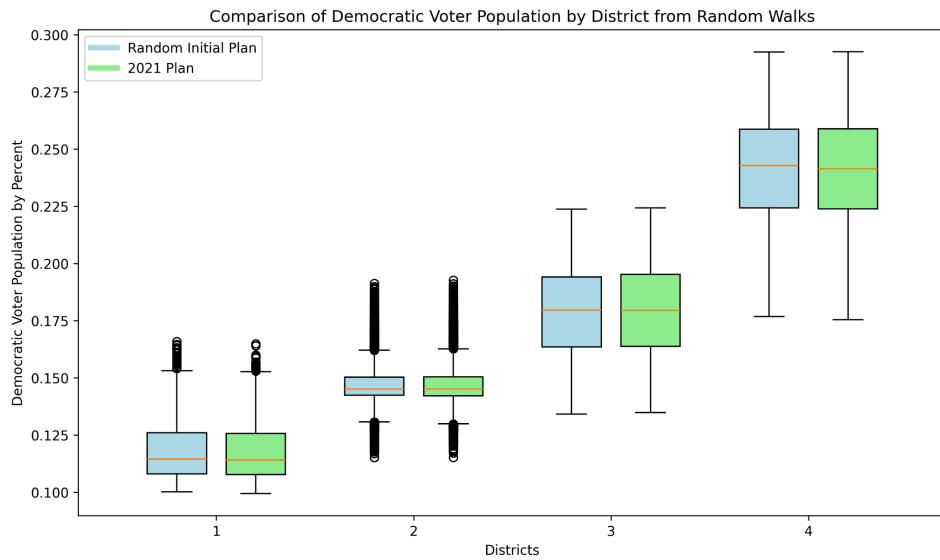
Using a random walk starting at a random initial districting plan, we ran our chain for 10,000 steps to explore the state space of Utah to find what districting plans were most likely. We found that the 2021 had 1 Democratic majority district, suggesting the 2021 plan was a partisan gerrymander.



Most Likely # of Democratic-Majority Districts in Utah, from a Random Plan

Mixing Time

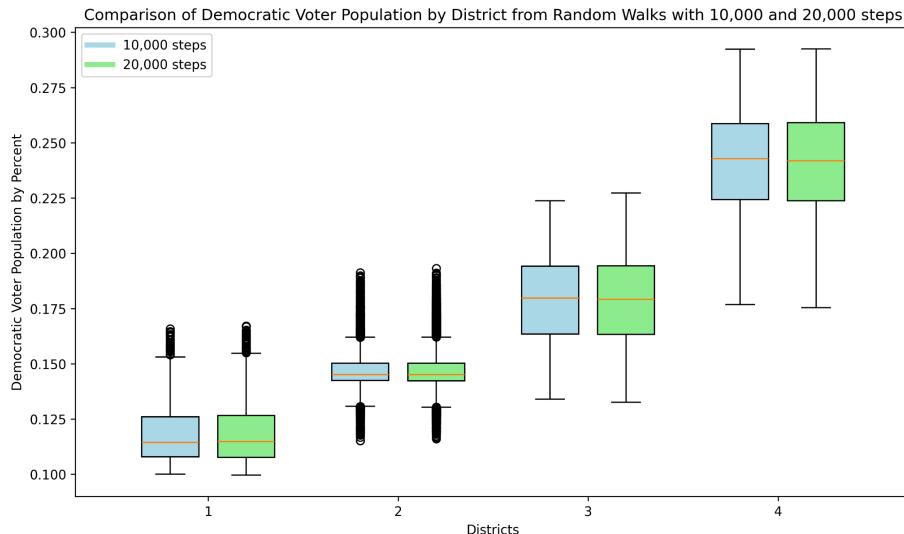
To ensure we ran our random walk for long enough, we compared the previous results to the distributions of results from a random walk starting at the 2021 plan. Below are box and whisker plots showing the outcome.



Distribution of Democratic Voter Population by Districts across Random Walks

Since the distribution for the districts for both random walks was very similar, we argued that running our walk for 10,000 steps was sufficiently long.

We also compared the results from our random walk for 10,000 steps to a random walk for 20,000 steps that started at the same random initial districting plan. The distributions for both the 10,000 step and 20,000 step random walks were similar, suggesting that running our random walk for more steps would not affect the outcome.



Distribution of Democratic Voter Population by Districts across Random Walks

Limitations

One limitation was that we used 2020 Presidential Data to predict voters' party preference in 2024. We were unable to use data from the 2022 Midterm elections since the U.S. Senate election was between Republican Mike Lee and Independent Evan McMullin, and we wanted to analyze Republican and Democrat voting likelihood. There were no other state-wide elections in 2022, so we had to go back to 2020. We had the option for Governor, Attorney General, or Presidential election, and we decided to use the Presidential Election because it was the most important.

Another limitation is that our ensembles do not have all the information. While they suggested that 1 Democratic district was most likely, a couple of plans did have 0 Democratic districts.

Conclusion

The ensemble analysis suggests that the districting plan in Utah was a partisan gerrymander, however we cannot conclude that as definitive. But for the purposes of our analysis, we will conclude that based on the ensemble analysis, in 2024, Utah should have elected 1 Democratic Representative instead of none.

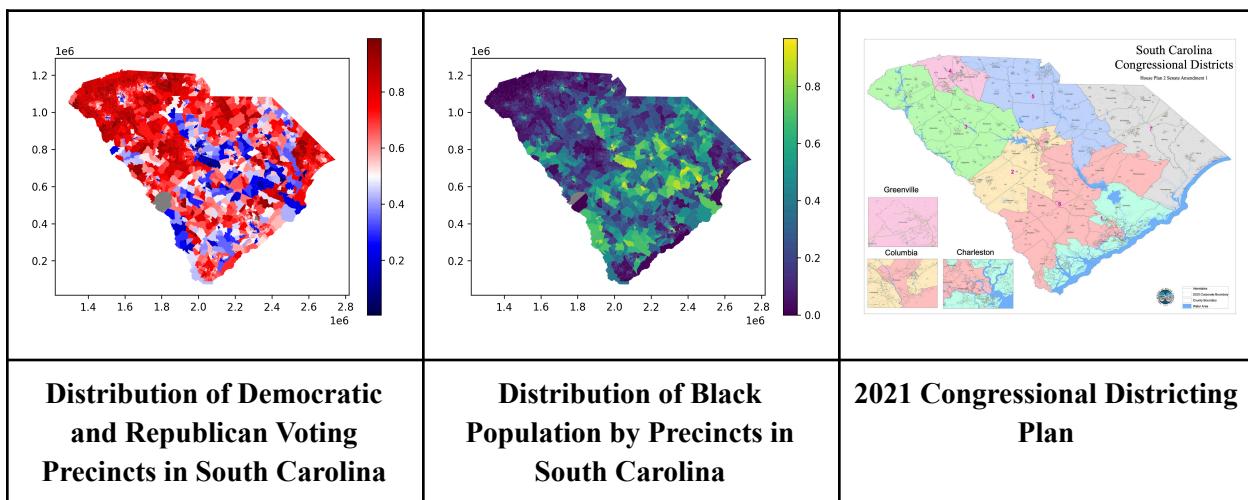
South Carolina

Background

In 2021, South Carolina passed their congressional districting plan following the 2020 census. In October of 2021, the South Carolina National Association for the Advancement of Colored

People (NAACP) filed a lawsuit saying that Congressional District 1 of the plan was a racial gerrymander. However, the case was dismissed with prejudice Aug 2024. Shortly before it was dismissed, in July, 2024, a new case was brought forth by the Women League of Voters of South Carolina claiming that the plan was a partisan gerrymander.

The graphic on the left represents the distribution of Democratic and Republican voters with bluer shapes meaning the precinct has more Democratic voters. Meanwhile, the graphic in the middle represents the distribution of the Black population in South Carolina by precincts with the more yellow representing a higher population of Black individuals.



Data

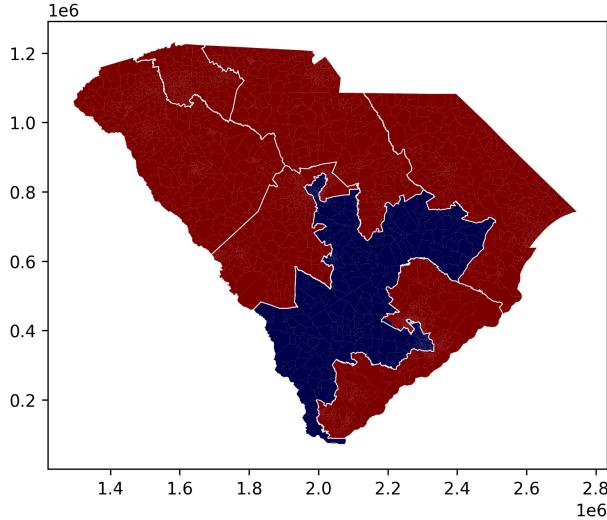
I downloaded the congressional district plan shapefile from the [South Carolina Redistricting 2021 Senate Judiciary Committee](#) website. It is the plan S.865 as passed by the S.C. General Assembly and signed by Governor McMaster.

I used the 2022 U.S. Senate Election results from the [Redistricting Data Hub](#). Then, I joined race demographics at the block level from the 2020 Census Data which I joined with block shapefile data from [Tiger/Shapefiles website](#), which I aggregated up to the precinct level to combine with the voting data. This provided me with a GeoDataFrame with precinct voting and demographic data for South Carolina which I could use to run and analyze my Markov Chain.

Analysis

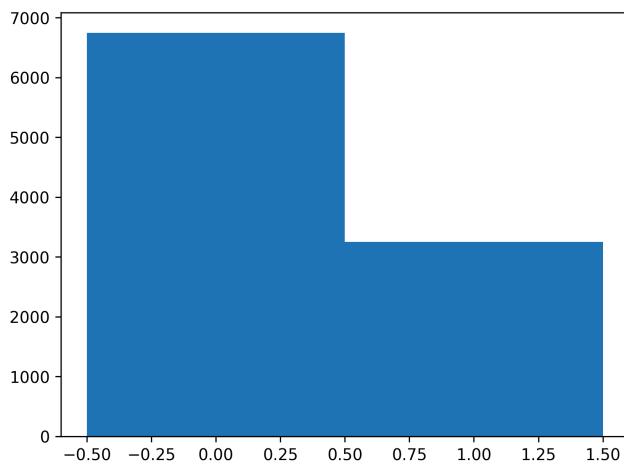
To analyze partisanship in South Carolina, we used the 2022 U.S. Senate Election results between Democrat Krystle Matthews and Republican Tim Scott. Using the 2021 plan and the votes from the 2022 Senate election, Democratic House candidates would have won in 1 district

while Republican candidates would have won in 6 districts. Furthermore, the 2021 plan had 1 Black majority district.

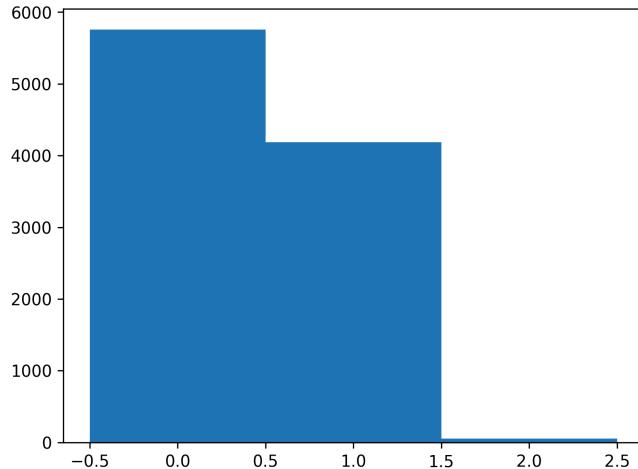


Original 2021 Plan - Democratic/Republican Districts

Using a random walk starting at a random initial districting plan, we ran our chain for 10,000 steps to explore the state space of South Carolina to find what districting plans were most likely. We found that 0 Democratic majority districts and 0 Black majority districts were most likely. Thus, our random walk seems to suggest that the plan was not a partisan gerrymander against the Democratic voting population or a racial gerrymander against the Black population.



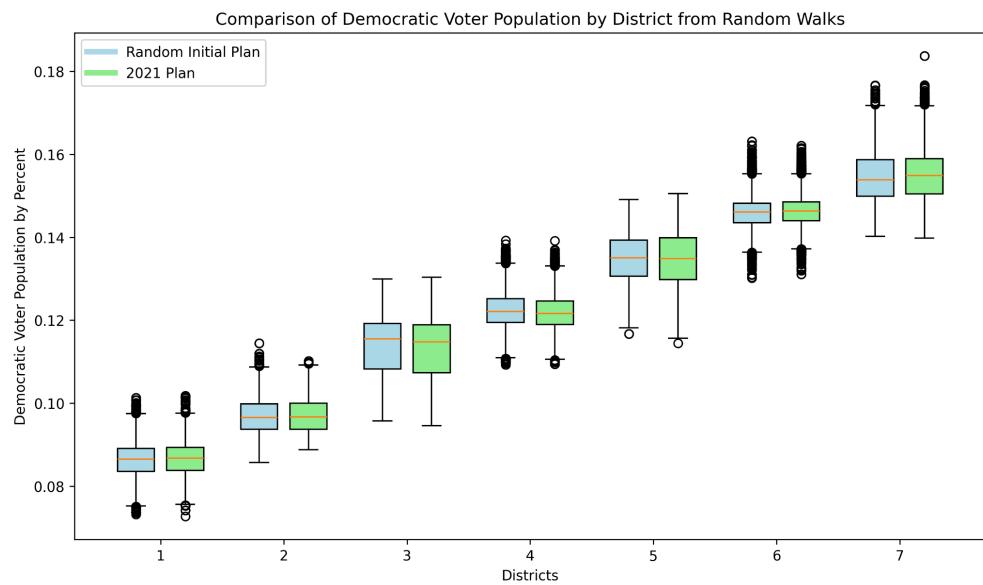
Most Likely # of Democratic-Majority Districts in South Carolina, from a Random Plan



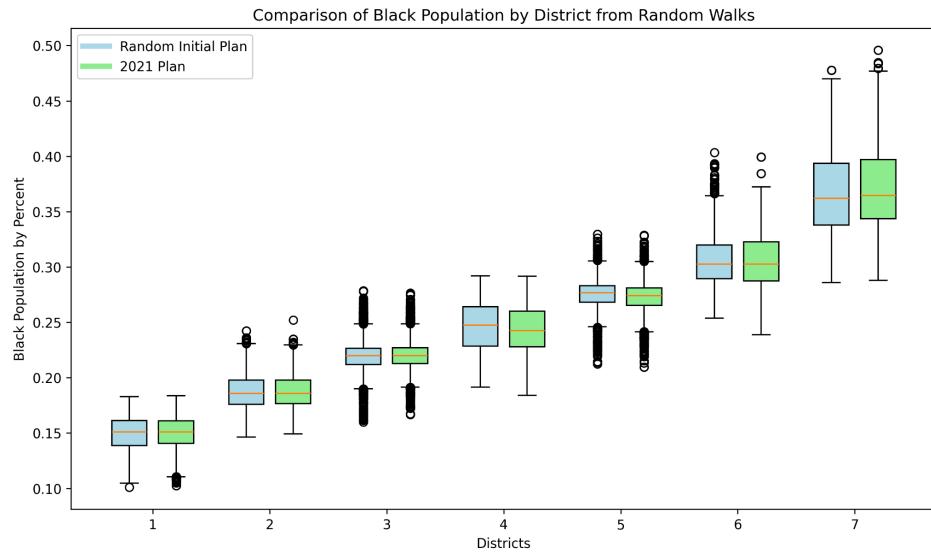
Most Likely # of Black-Majority Districts in South Carolina, from a Random Plan

Mixing Time

To ensure we ran our random walk for long enough, we compared the previous results to the distributions of results from the random walk starting at both the 2021. Below are box and whisker plots showing the outcome.



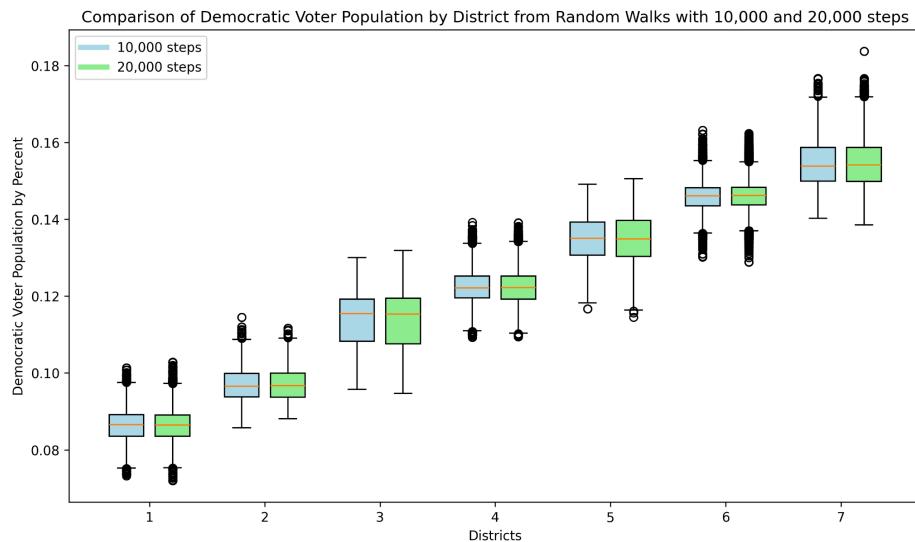
Distribution of Democratic Voter Population by Districts across Random Walks



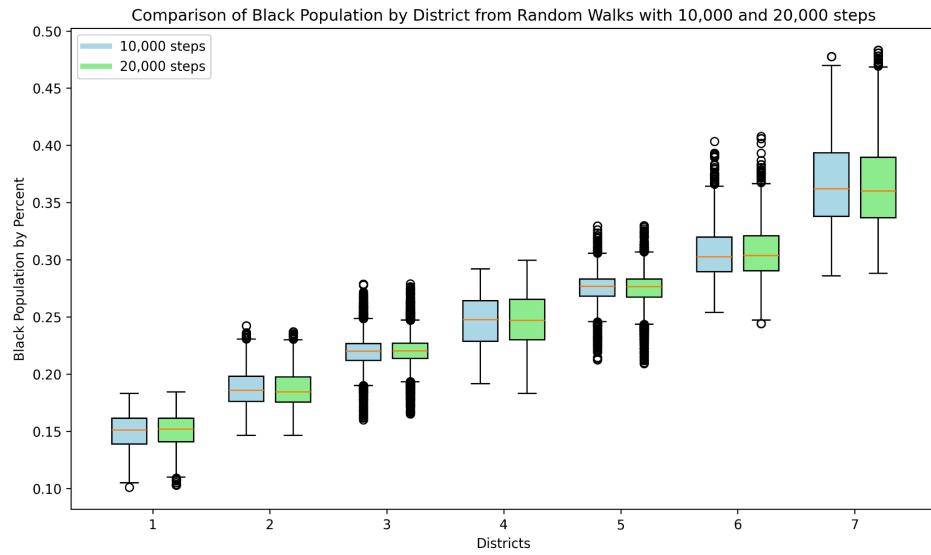
Distribution of Black Population by Districts across Random Walks

Since the distribution for the districts across all three random walks is very similar, we argued that running our walk for 10,000 steps was sufficiently long.

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Distribution of Democratic Voter Population by Districts across Random Walks



Distribution of Black Voter Population by Districts across Random Walks

Limitations

One limitation in our predictions was that we used data from 2022 to predict voter party preference two years later. We are assuming voters' party preference would stay the same and are not taking into account how time or candidates could affect how a voter votes.

Furthermore, although our ensemble suggests that there should be 0 Democratic majority districts in South Carolina, our ensemble did suggest that 1 Democratic district was feasible. Similarly, while the ensemble suggested that 0 Black majority districts was most likely, it did include 1 and even 2 Black majority districts as possibilities. However, our ensemble does not have all the information so if it had all information, it could have a different distribution of most likely plans.

Conclusion

The ensemble analysis suggests that the districting plan in South Carolina was not a partisan and racial gerrymander. For the purposes of our analysis, we will conclude that based on the ensemble analysis, in 2024, South Carolina should have 0 Democratic districts (instead of the 1 district that elected a Democratic Representative in 2024) as well as 0 Black majority districts.

North Carolina

Background:

After the 2020 Census, the North Carolina Legislature created a new political districting map. This map created 3 likely Democratic districts and 11 likely Republican districts. This plan was immediately taken to court over the idea that it was a political gerrymander due to North Carolina state law, which prevented the right to fair maps. The North Carolina Supreme Court then agreed, stating that the maps were illegal and must be redrawn. Further, they required that a temporary map be drawn by the Courts for use in the 2022 election. This new map increased the number of likely Democratic districts to 7, providing a fair split of districts to each party.

After the 2022 elections, the North Carolina Supreme Court was shifted from a Democratic majority (that had ruled earlier) to a Republican majority. They then overturned the previous ruling, arguing that partisan gerrymandering was not something for the courts to consider, and thus allowing the North Carolina legislature to do whatever they would like.

This led to the current plan, used in the 2024 elections. This plan was expected to have 3 likely Democratic districts and 11 likely Republican districts. In a surprise to the state, an additional district voted for a Democratic district, bringing the total to 4 Democratic Representatives and 10 Republican Representatives.

Objective: This analysis aims to determine whether there is evidence that North Carolina politically gerrymandered their Congressional Districts in 2020.

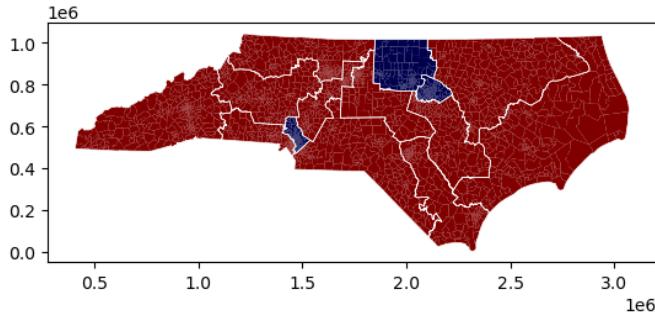
Data:

I focused on three different Congressional Districting Plans enacted by North Carolina: the original plan (never used in an election), the court-created temporary plan (used in the 2022 election), and the current plan (used in the 2024 election).

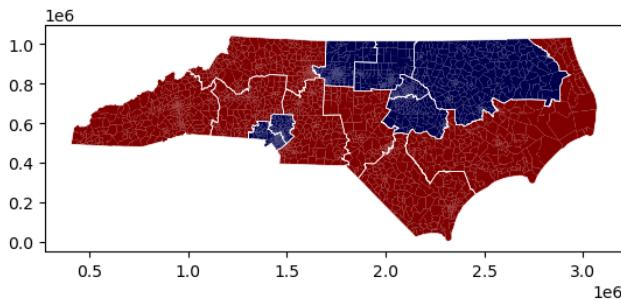
I collected the precinct dataset from [Redistricting Data Hub](#), which had collected the precinct-level 2022 election results and boundaries from the North Carolina State Board of Elections.

I then combined this precinct voting dataset with the three congressional districting plans. I found Shapefiles for each of the plans from the [North Carolina General Assembly's Redistricting website](#).

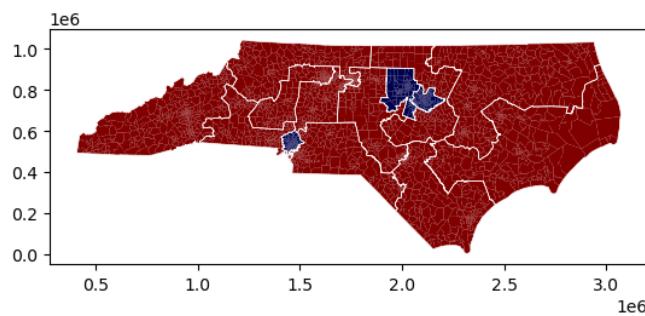
After combining those shapefiles into a new GeoDataFrame, I combined it with the Census Data. The [Census Data](#), provided by the US Census Bureau, is in Block form. I first had to join the Census Data to a [Shapefile with Block to Precinct](#) matching (from the 2022 TIGER/Line Shapefiles Website), then aggregate the block census data up to the precinct level. Finally, I combine the aggregated precinct census data with the precinct voting and congressional districting data. This allowed me to have one Geodataframe with all the necessary information to conduct my analysis.



Original Plan - Democratic/Republican Districts



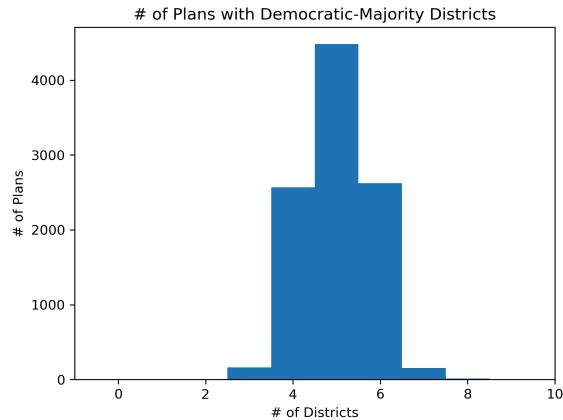
2022 Plan - Democratic/Republican Districts



2024 Plan - Democratic/Republican

Analysis:

According to the Ensemble Analysis, 5 districts should have a Democratic Majority. I conducted a ReCom random walk from the Adopted plan (for 10,000 and 20,000 steps), the Temporary plan (for 10,000 steps), and a random plan (for 10,000 steps). All four of these had a majority of plans with 5 democratic-majority districts. 4 and 6 districts were also likely, whereas 3 and 7 were possible but not likely.

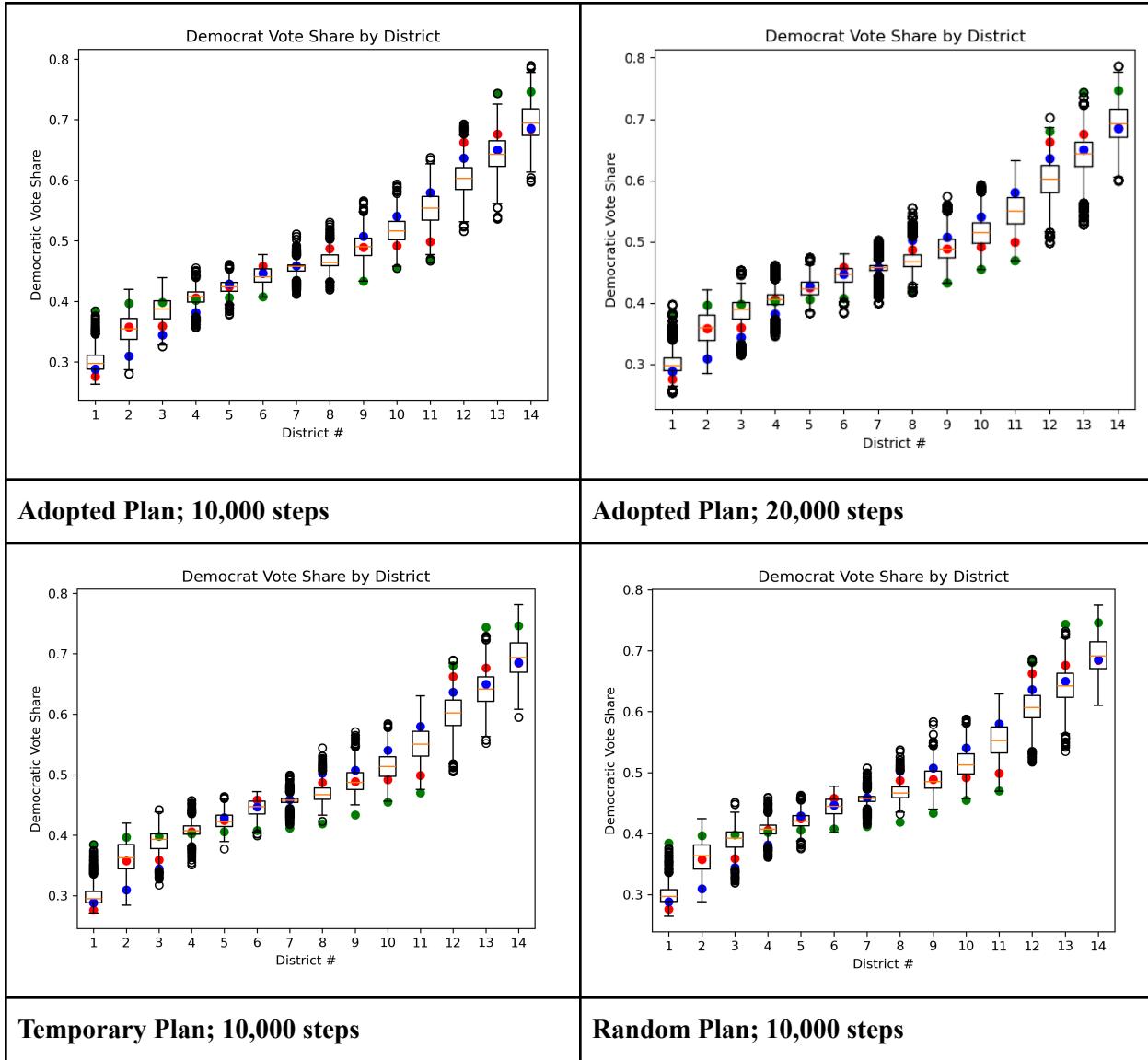


Most Likely # of Democratic-Majority Districts in North Carolina, from a Random Plan

If we were to use the ensemble recommendations in the 2024 election, North Carolina would have an additional Democratic district. In the 2024 General Elections, North Carolina elected the Democratic candidate in 4 out of the 14 districts. However, our ensemble recommends 5 Democratic districts as the most reasonable districting distribution. Therefore, a new plan based on our ensemble would flip one Republican seat to a Democratic seat.

Mixing Time:

I ran multiple different random walks, with various starting plans and running lengths, to ensure that our ensemble was completely mixed. For each random walk, I created a box-and-whiskers plot detailing the percentage of Democratic votes in each district. I have included the box-and-whiskers plot for all four runs. Because I got very similar results between all four, it concludes that the Markov Chain is close to stationary at 10,000 steps.



Limitations:

Although the Ensemble plan recommends five Democratic seats, electing four does not mean that there is a political gerrymander. Our ensemble analysis shows that although five seats are the most likely, four seats are still a possible (and somewhat likely) outcome. Therefore, we can not conclude that a political gerrymander occurred in North Carolina in the adopted plan.

Further, we do not have sufficient evidence that the original plan was also a political gerrymander. As noted above, the possibility of having 3 seats did appear. Although it was unlikely, it is much more likely than one or two Democratic seats. In addition, we are not sure

that we have all the information. Because we were using data from the 2022 election, we do not know how individual votes changed in the 2024 election.

Conclusion:

Although there is evidence to suspect political gerrymandering, there is not clear and convincing evidence that political gerrymandering occurred in North Carolina. Because we are unsure if our random walk has all the necessary information, along with the fact that we did see some plans with three democratic districts, we can not conclude that there was an obvious gerrymander.

However, for purposes of our analysis, we can conclude that creating a plan based on the ensemble would increase the number of Democratic districts in North Carolina by one.

Florida

Background:

After the 2020 Census, the Florida legislature proposed two districting plans for the US Congressional Districts. The primary plan, H00C8109, was put forward, but a secondary plan, H00C8015, was also proposed in case the first plan was invalidated. This invalidation would have occurred over Congressional District 5. Before 2020, this district was a primarily-Black district. The primary plan is argued to have cracked the Black voters into two different districts, therefore invalidating their ability to have a meaningful say.

After both of these plans (the primary and secondary) were proposed, the Florida governor vetoed these plans. Instead, he created a Special Session of the Florida Legislature to create a new map, P000C0109. It was during this session that the official map, used in both the 2022 and 2024 elections, was created.

Shortly after, plaintiffs took this case to court, arguing that it was a racial gerrymander. Florida has a “Fair Districts Amendment”, which forbids racial gerrymandering. To note, in 2012, the Supreme Court ruled that if a minority-majority district already exists, a state legislature can not dismantle this district. However, the Florida District Court of Appeals did not apply this reasoning, instead stating that maintaining a minority-majority district would require a non-geographically compact district.

This case is currently in the hands of the Florida Supreme Court to decide whether the District Court of Appeals properly applied the legislation over the plan. In the meantime, P000C0109 continues to be used.

Objective: This analysis aims to determine whether there is evidence that Florida racially gerrymandered their Congressional Districts in 2020.

Data:

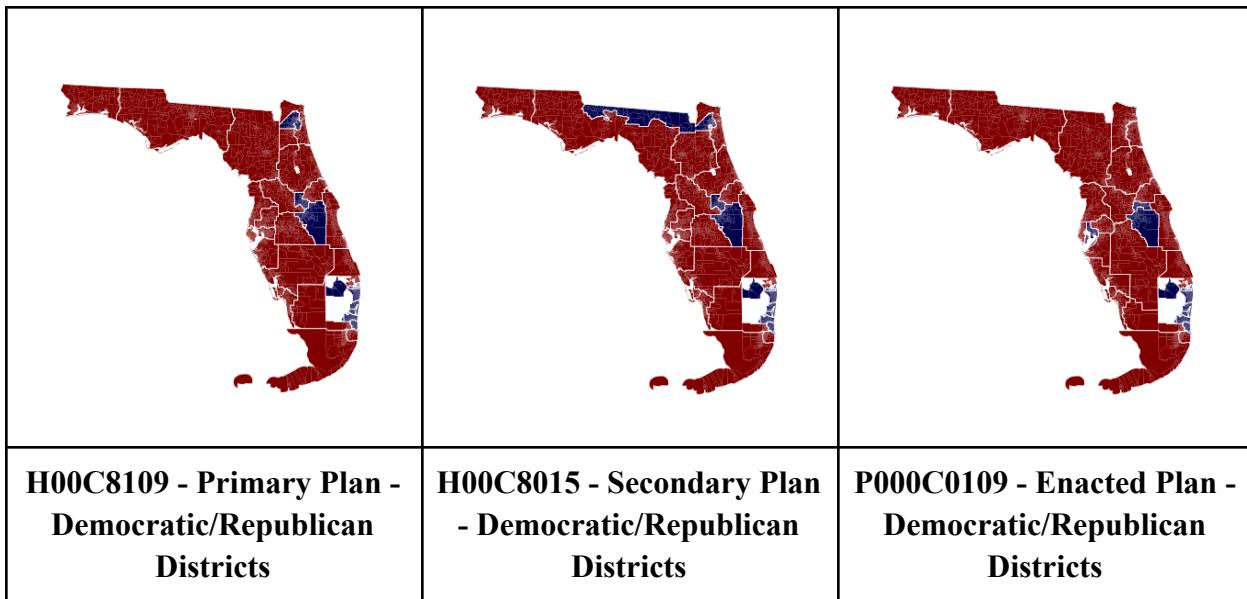
I focused on three different Congressional Districting Plans enacted by Florida, as detailed above: H00C8109 (the primary proposal), H00C8015 (the secondary plan), and P000C0109 (the current plan used in both the 2022 and 2024 election).

I collected the precinct dataset from [Redistricting Data Hub](#), which had collected the precinct-level 2022 election results and boundaries from the Florida Division of Elections.

I then combined this precinct voting dataset with the three congressional districting plans. I found Shapefiles for each of the plans from the [Florida Redistricting website](#).

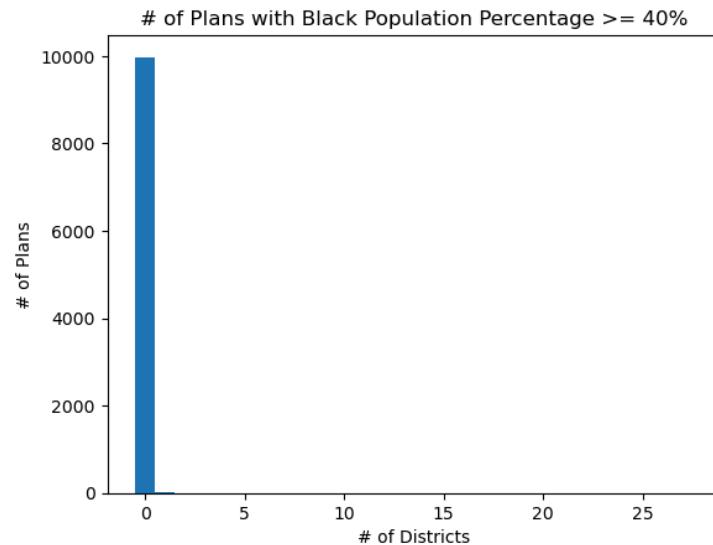
After combining those shapefiles into a new GeoDataFrame, I combined it with the Census Data. The [Census Data](#), provided by the US Census Bureau, is in Block form. I first had to join the Census Data to a [Shapefile with Block to Precinct](#) matching (from the 2022 TIGER/Line Shapefiles Website), then aggregate the block census data up to the precinct level.

Finally, I combine the aggregated precinct census data with the precinct voting and congressional districting data. This allowed me to have one Geodataframe with all the necessary information to conduct my analysis.



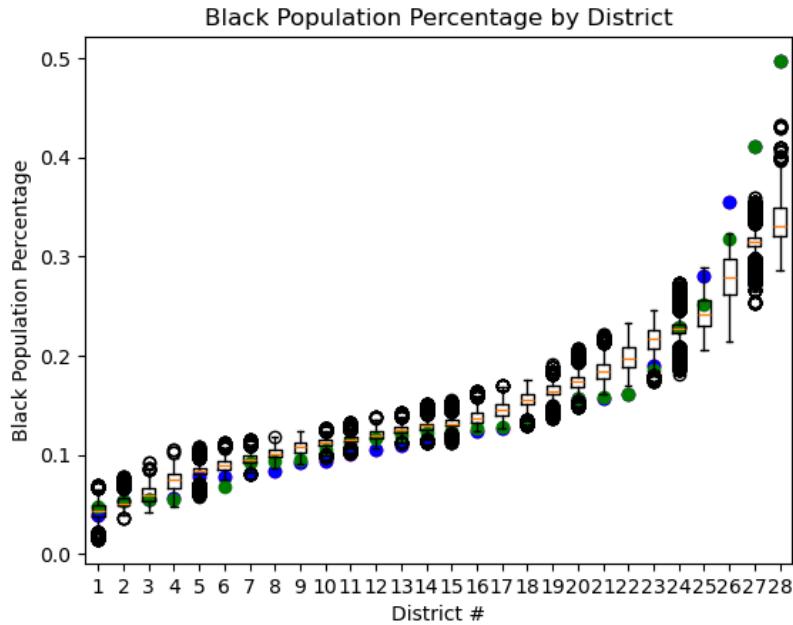
Analysis:

According to the Ensemble Analysis, 0 districts should have a black minority-majority (greater than 40%). I conducted a ReCom random walk from the Adopted plan (for 10,000 steps), the Original plan (for 10,000 and 20,000 steps), and two different random plans (for 10,000 steps). All five of these had a majority of plans with zero minority-majority Black districts. Each of these plans did have the possibility of one black minority-majority district, but this was not likely.



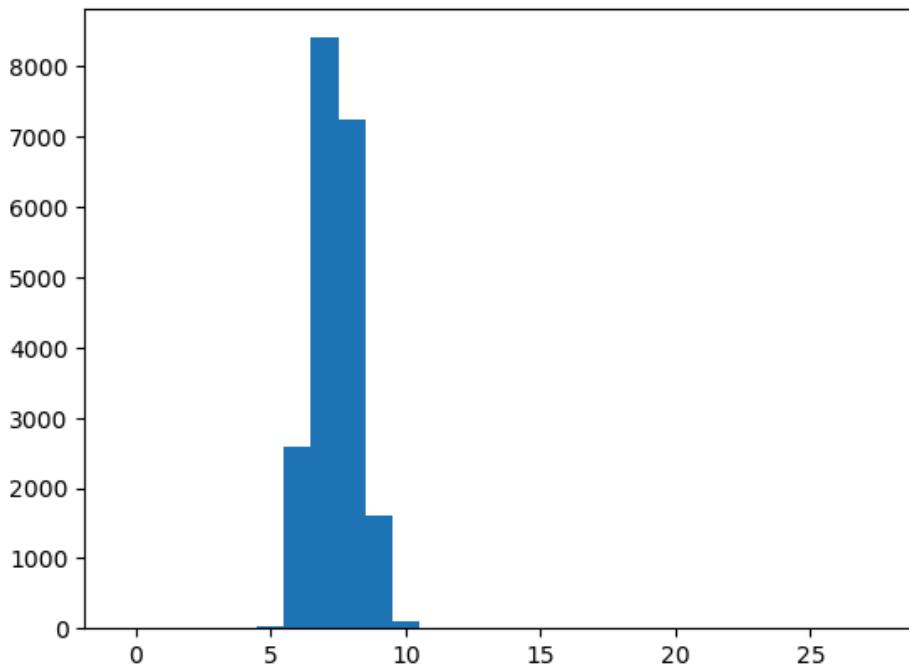
Most Likely # of Black Minority-Majority Districts in Florida, from a Random Plan

To examine this further, I also created a box-and-whiskers plot of the Black population percentage, which shows that having a black minority-majority district would be an outlier.



Percentage of Black People per District in Florida, from a Random Plan (Red = 2022 Plan; Green = 2024 Plan)

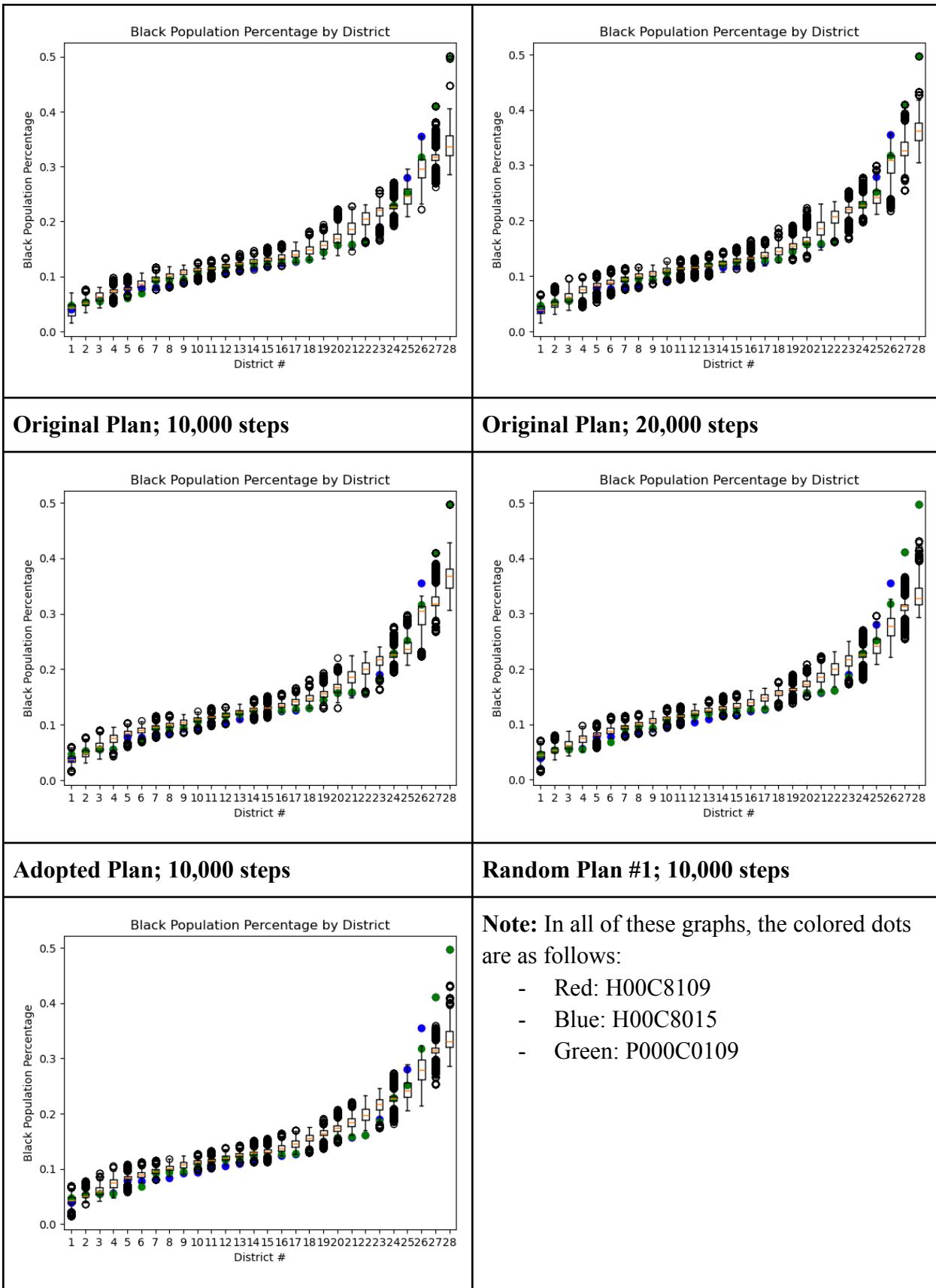
Although this court case was regarding racial gerrymandering, I wanted to examine how a Markov Chain random walk on the map of Florida would impact the number of Democratic districts. Every plan recommended 7 Democratic districts, with 5, 6, 8, and 9 also being a valid choice. In all of the plans put forth by the Florida legislature, there are 8 Democratic districts. Therefore, if we were to use the ensemble recommendations in the 2024 election, one seat would flip to a Republican seat from a Democratic seat.



Most Likely # of Democratic Majority Districts in Florida, from a Random Plan

Mixing Time:

I ran multiple different random walks, with various starting plans and running lengths, to ensure that our ensemble was completely mixed. For each random walk, I created a box-and-whiskers plot detailing the percentage of Democratic votes in each district. I have included the box-and-whiskers plot for all five runs. Because I got very similar results between all four, it concludes that the Markov Chain is close to stationary at 10,000 steps.



Random Plan #2; 10,000 steps	
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Limitations:

The first limitation in this analysis occurred in the set-up of the map, as I had to connect certain precincts to others by hand. As Florida is on the water, there are many islands. To run the ensemble analysis, I had to manually create edges, or connections, between these islands and the closest mainland precinct. To do this, I found precinct-level maps for each county that contained an unconnected island and visually identified the closest precinct. Although I did this to the best of my ability, I might have connected these precincts in different ways than the plans did and thus added a limitation to this analysis.

Although our Ensemble does not recommend having a Black minority-majority district, this does not mean that there should not be one. One of the current contentions in the Political Districting landscape is overforming minority-majority districts. Should there be a requirement to form a minority-majority district if it is possible, even if it is not likely? Although the Supreme Court recently ruled that the answer to that question should be yes, it is taking some time for this ruling to be applied universally. In addition, it is not clear whether the circumstances of that ruling are specific, meaning that some lower courts are still ruling with an answer of no to that question. In this ensemble, we do not emphasize forming minority-majority districts, thus effectively answering no to this question.

Although the Ensemble plan recommends seven Democratic seats, electing eight does not mean that there is a political gerrymander. Similar to the discussion in the paragraph above, requiring the formation of a minority-majority district would most likely lead to an additional Democratic seat. Additionally, although seven was the most likely, eight was not impossible. This means that eight Democratic seats is not unreasonable, and therefore can't be automatically ruled as a political gerrymander.

Conclusion:

There is no evidence to suspect racial gerrymandering when considering the Ensemble Analysis. However, this does not mean that there is no evidence. When considering the changes in districts from pre-2020 Congressional Districts and the new plans, it is clear that one minority-majority district was broken up. However, is this evidence to prove that racial gerrymandering occurred? And if so, why is it not reflected in our ensemble analysis? These are active questions to consider in a future research project.

For purposes of our analysis, we can conclude that creating a plan based on the ensemble would decrease the number of Democratic districts in Florida by one.

Louisiana

Background:

Louisiana first enacted a plan with one Black majority district. This districting plan was reminiscent of the plan used before the 2020 Census. However, one-third of the state's population is Black, meaning that only one minority-majority district out of six congressional districts is not an accurate representation of the Louisiana population. This map was used in the 2022 General Election.

However, the map was challenged for failing to make a second Black-majority district. The Supreme Court ruled that Louisiana must make a new map with two Black-majority districts before the 2024 Election. Although they complied, the second district they created was extremely long and narrow (and not geographically compact) because they wanted to keep certain Republican representatives in office.

This case is still in litigation, as a court ruled that the new plan is a racial gerrymander. This court argues that race was a consideration in making the new districting plan, and thus is a racial gerrymander. The Supreme Court has agreed to hear the case, and a decision is expected in 2025.

Objective: This analysis aims to determine whether there is evidence that Louisiana racially gerrymandered its Congressional Districts in the 2022 and 2024 plans.

Data:

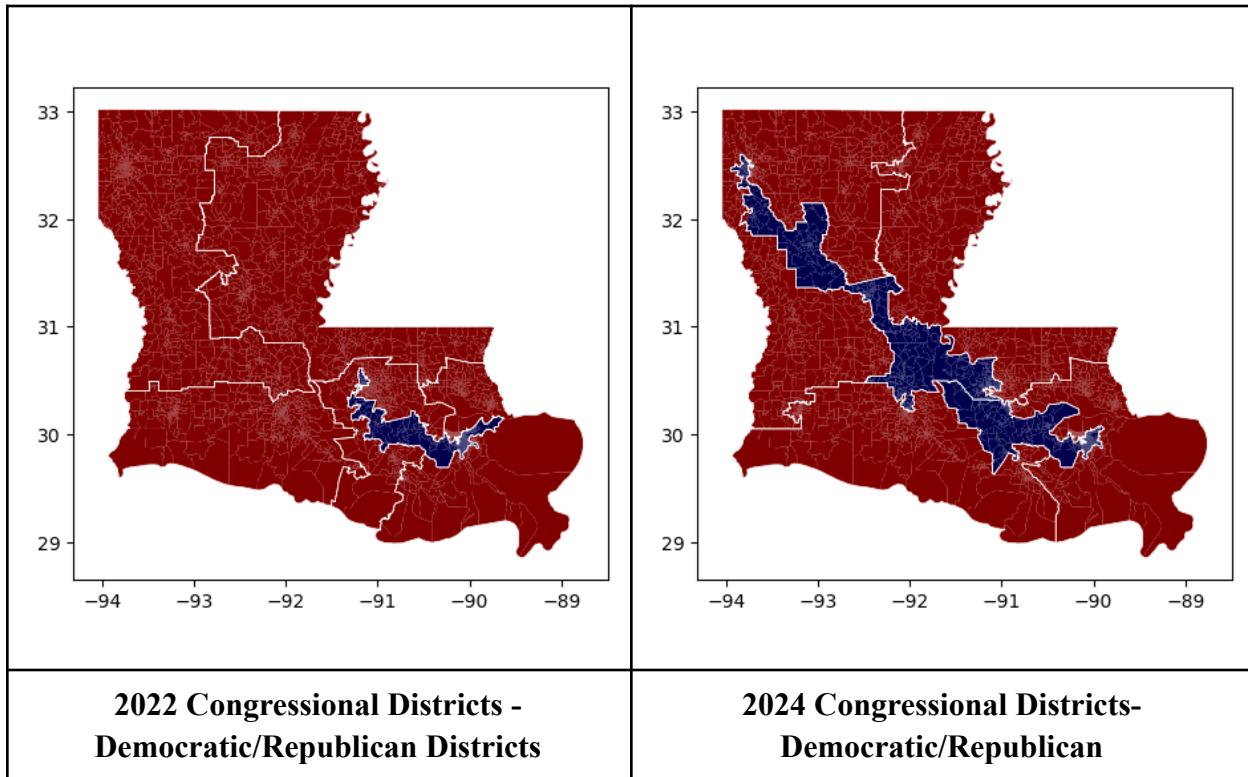
I focused on two different Congressional Districting Plans enacted by Louisiana, as detailed above: the plan used in the 2022 election and the plan used in the 2024 election.

I collected the precinct dataset from [Redistricting Data Hub](#), which had collected the precinct-level 2022 election results and boundaries from the Louisiana Secretary of State.

I then combined this precinct voting dataset with the two congressional districting plans. I found Shapefiles for each of the plans from the [Louisiana Redistricting Website](#).

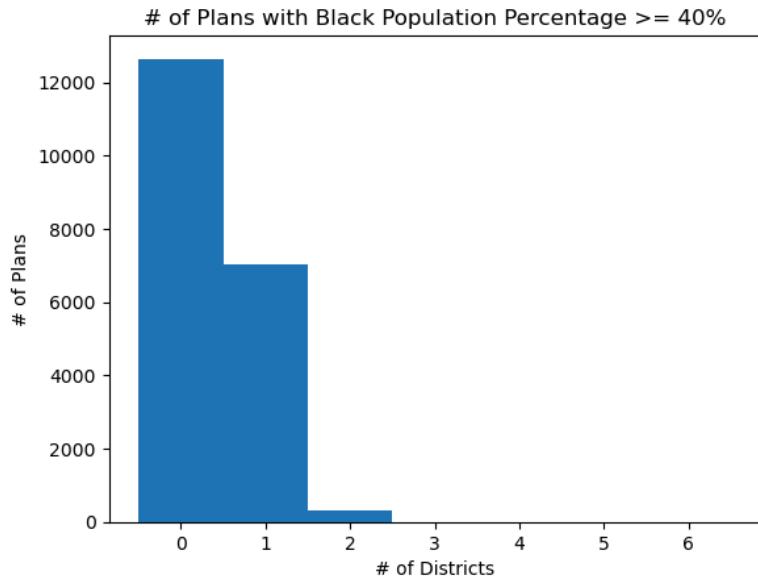
After combining those shapefiles into a new GeoDataFrame, I combined it with the Census Data. The [Census Data](#), provided by the US Census Bureau, is in Block form. I first had to join the Census Data to a [Shapefile with Block to Precinct](#) matching (from the 2022 TIGER/Line Shapefiles Website), then aggregate the block census data up to the precinct level.

Finally, I combine the aggregated precinct census data with the precinct voting and congressional districting data. This allowed me to have one Geodataframe with all the necessary information to conduct my analysis.



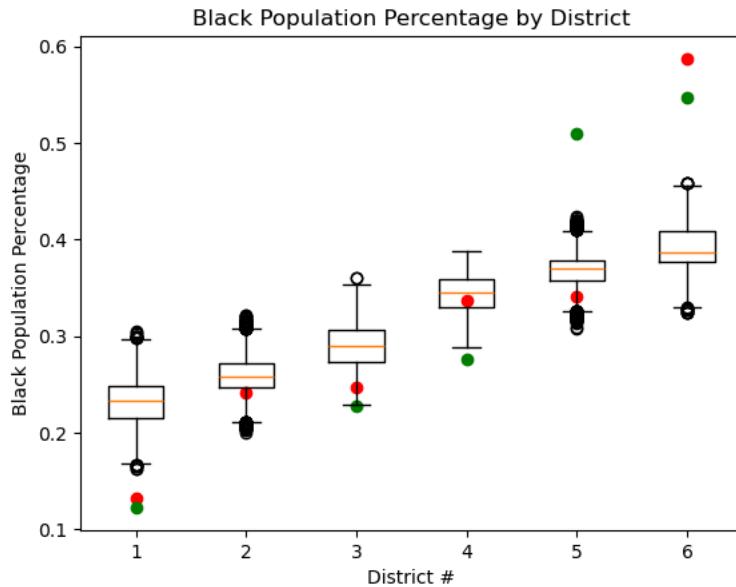
Analysis:

According to the Ensemble Analysis, 0 districts should have a black minority-majority (greater than 40%). I conducted a ReCom random walk from the Original plan (for 20,000 and 40,000 steps) and two different random plans (for 20,000 steps). All five of these had a majority of plans with zero minority-majority Black districts. Each of these plans did have the possibility of one black minority-majority district, but this was not as likely.



Most Likely # of Black Minority-Majority Districts in Louisiana, from a Random Plan

To examine this further, I also created a box-and-whiskers plot of the Black population percentage, which shows that having either one or two black minority-majority districts would be an outlier.



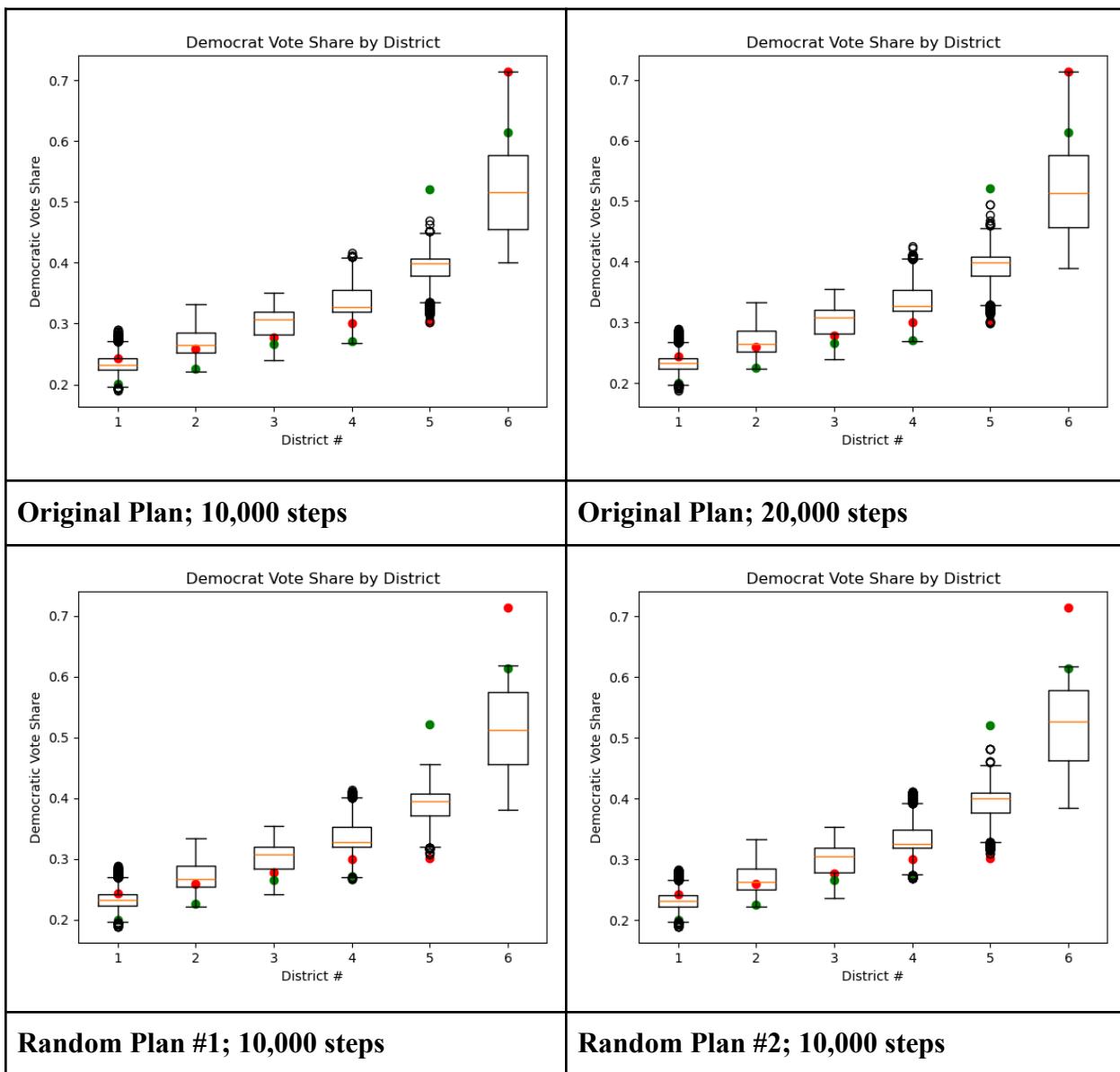
Percentage of Black People per District in Louisiana, from a Random Plan (Red = 2022 Plan; Green = 2024 Plan)

Although this court case was regarding racial gerrymandering, I wanted to examine how a Markov Chain random walk on the map of Louisiana would impact the number of Democratic districts. Every plan recommended 1 Democratic district, with 0 also being a valid choice. In the

2022 Plan, there was one Democratic district. In the 2024 Plan, there were two Democratic districts. If we were to modify the 2024 election results based on the ensemble, one Democratic seat would be flipped to Republican.

Mixing Time:

I ran multiple different random walks, with various starting plans and running lengths, to ensure that our ensemble was completely mixed. For each random walk, I created a box-and-whiskers plot detailing the percentage of Democratic votes in each district. I have included the box-and-whiskers plot for all five runs. Because I got very similar results between all four, it concludes that the Markov Chain is close to stationary at 10,000 steps.



Limitations:

Although the most likely possibility in our ensemble is to have no minority-majority districts, this does not mean that having one or two is a sign of racial gerrymandering. As discussed above, one minority-majority district was also a possibility. Additionally, there may be inconsistencies in our data or how we create the ensemble that would reduce the likelihood of a minority-majority district occurring. Similarly as discussed in Florida, there is also the question (and ongoing debate) of whether a minority-majority district should be formed because it can be formed, or because it is the most likely occurrence.

Conclusion:

There is not enough evidence to suggest racial gerrymandering when considering the Ensemble Analysis, but our initial ensemble suggests that two minority-majority districts is not a common occurrence. When considering the change in plans from 2022 to 2024, we see a new minority-majority district formed that is not geographically compact.

For purposes of our analysis, we can conclude that creating a plan based on the ensemble would decrease the number of Democratic districts in Louisiana by one.

Arkansas

Background:

After the 2020 Census, Arkansas's new plan divided up the state into four Congressional Districts. This plan contained all likely Republican districts and no minority-majority districts. This plan was then challenged for cracking Black voters in Pulaski County. Originally kept together, this new districting plan divided southeast Little Rock into three different districts.

Although the defendants argue that no plan can be made with a minority-majority district, the plaintiffs are continuing with the lawsuit. They argue that even a 30 or 40% black population will allow a greater influence on the chosen representative.

This map was allowed to be used in both the 2022 and 2024 elections. The lawsuit is ongoing, as a three-panel judge just finished listening to both parties. A decision on next steps is expected in the Spring, but the case is not expected to be concluded until later.

Objective: This analysis aims to determine whether there is evidence that Arkansas racially gerrymandered its Congressional Districts in the 2022 and 2024 plans.

Data:

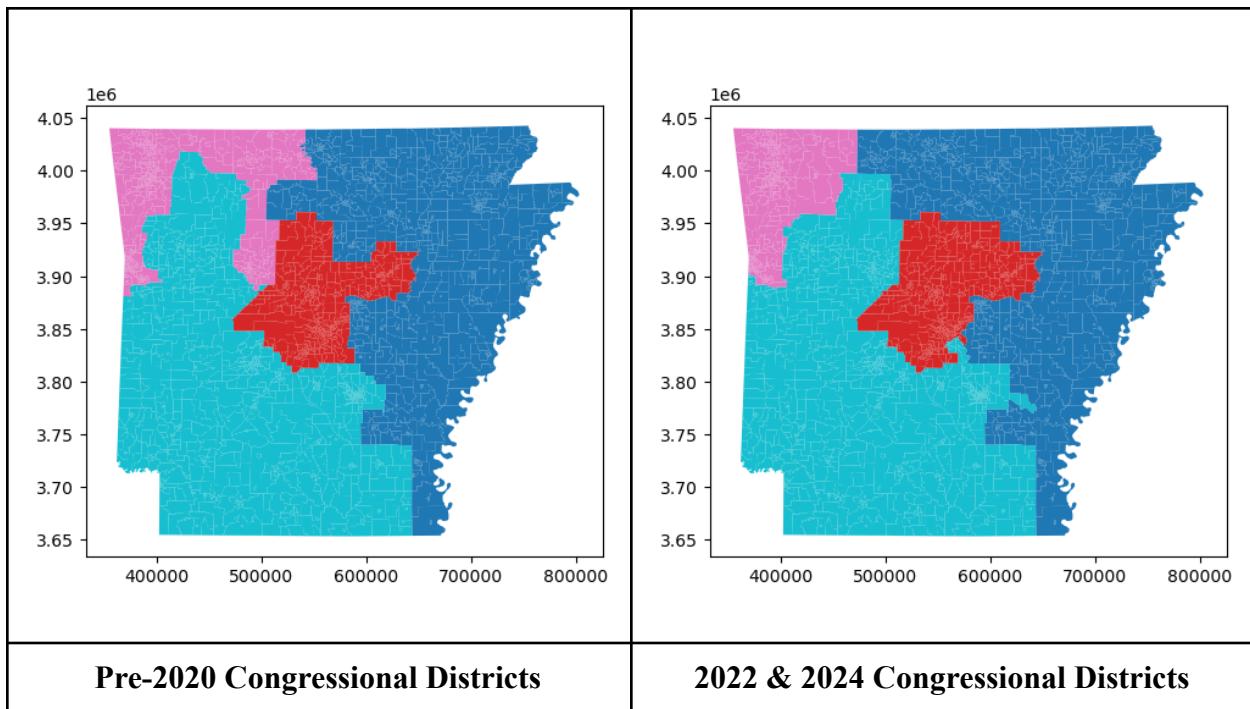
I focused on two different Congressional Districting Plans enacted by Arkansas, as detailed above: the plan used before the 2022 election and the plan used in both the 2022 and 2024 elections.

I collected the precinct dataset from [Redistricting Data Hub](#), which had collected the precinct-level 2020 election results from the Voting and Election Science Team and boundaries from the Redistricting Data Hub.

I then combined this precinct voting dataset with the two congressional districting plans. I found Shapefiles for each of the plans from the [Redistricting Data Hub](#).

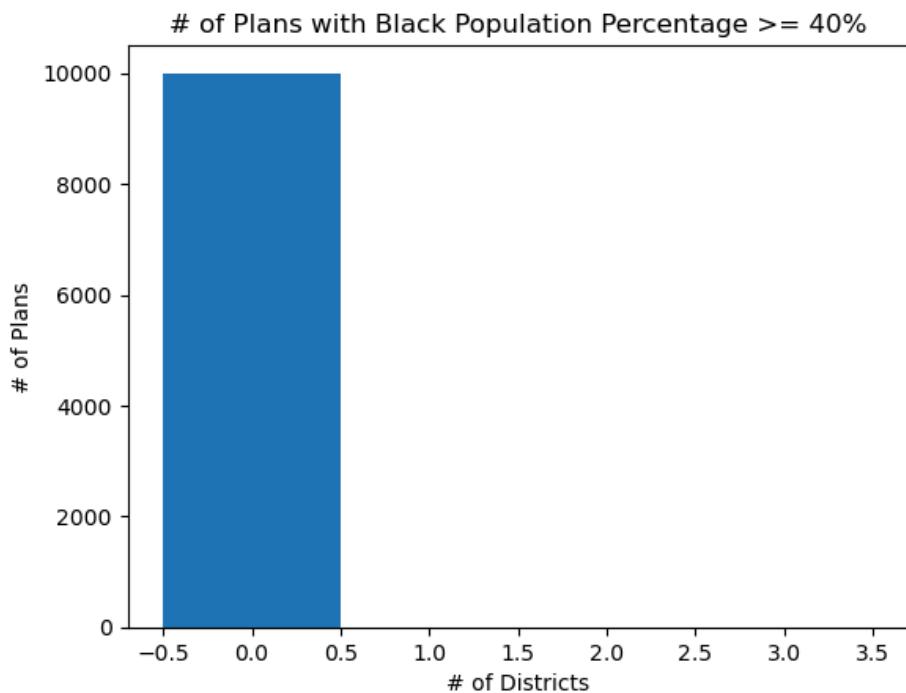
After combining those shapefiles into a new GeoDataFrame, I combined it with the Census Data. The [Census Data](#), provided by the US Census Bureau, is in Block form. I first had to join the Census Data to a [Shapefile with Block to Precinct](#) matching (from the 2022 TIGER/Line Shapefiles Website), then aggregate the block census data up to the precinct level.

Finally, I combine the aggregated precinct census data with the precinct voting and congressional districting data. This allowed me to have one Geodataframe with all the necessary information to conduct my analysis.



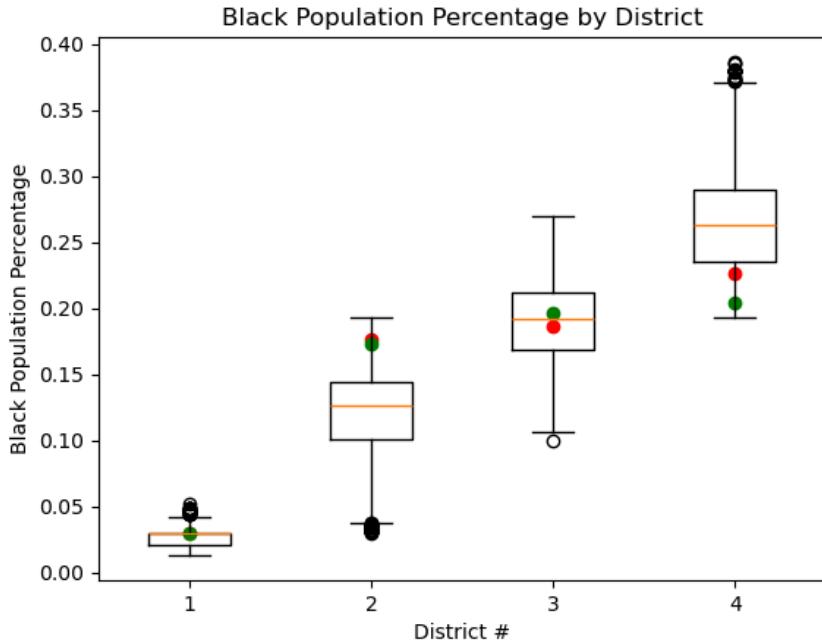
Analysis:

According to the Ensemble Analysis, 0 districts should have a black minority-majority (greater than 40%). I conducted a ReCom random walk from the Adopted plan (for 10,000 and 20,000 steps) and a random plan (for 10,000 steps). All three of these had all plans with zero minority-majority Black districts.



Most Likely # of Black Minority-Majority Districts in Arkansas, from a Random Plan

To examine this further, I also created a box-and-whiskers plot of the Black population percentage, which shows that having one black minority-majority district would be an outlier.

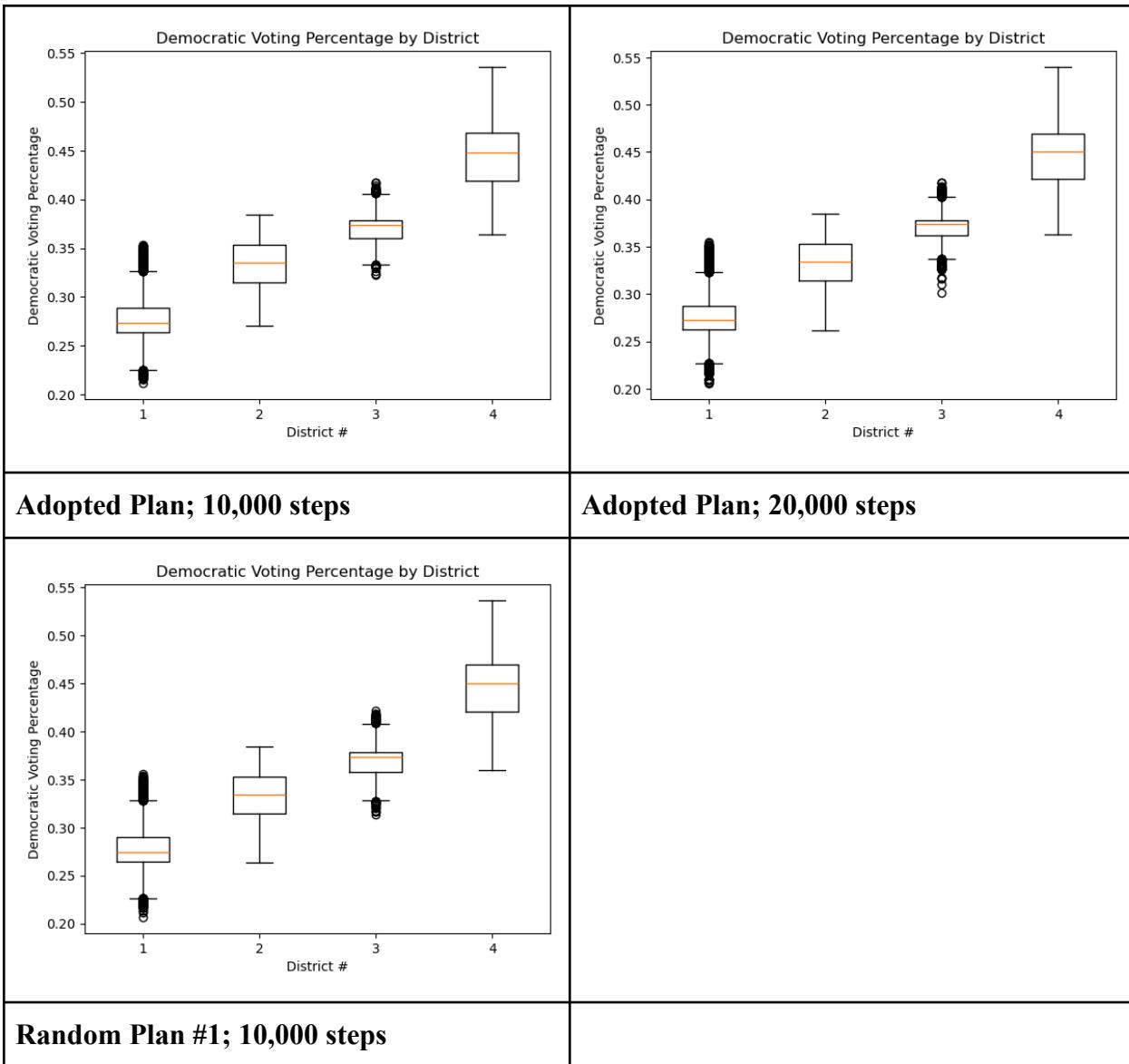


Percentage of Black People per District in Arkansas, from a Random Plan
(Red = Pre-2020 Plan; Green = 2022 & 2024 Plan)

Although this court case was regarding racial gerrymandering, I wanted to examine how a Markov Chain random walk on the map of Arkansas would impact the number of Democratic districts. Every plan recommended 0 Democratic districts, with 1 also being a valid (albeit unlikely) choice. In the 2022 and 2024 Plans, there were zero Democratic districts. If we were to modify the 2024 election results based on the ensemble, no seats would change.

Mixing Time:

I ran multiple different random walks, with various starting plans and running lengths, to ensure that our ensemble was completely mixed. For each random walk, I created a box-and-whiskers plot detailing the percentage of Democratic votes in each district. I have included the box-and-whiskers plot for all five runs. Because I got very similar results between all four, it concludes that the Markov Chain is close to stationary at 10,000.



Limitations:

Arkansas only released the 2022 General Election results by county, not precinct. Because a finer level of detail was necessary for our ensemble, I instead had to use the Presidential election data from 2020. At the time of analysis, this data is now four years old. Therefore, it is hard to believe that Arkansas voters have remained the same in the past four years.

Although I have continued with the analysis, the results can not be considered accurate due to this data discrepancy. As many other states have been analyzed using 2022 data, we can not conclude that the results should be the same between 2020 and 2022 data.

Conclusion:

There is no evidence to suggest that racial gerrymandering occurred when Arkansas enacted its Congressional Districting plan. However, this claim is subject to limitations regarding the availability of 2022 data, and the necessity to use 2020 data.

For our analysis, we can conclude that creating a plan based on the ensemble would keep Arkansas's number of seats in the House the same.

Alabama

Background:

Alabama initially created a Congressional Districting plan, following the 2020 Census, that ensured one Black-majority district. However, this was immediately taken to court over the Voting Rights Act, arguing that Alabama failed to create a second Black-majority district that could have been made. In February of 2022, the Supreme Court issued a stay, allowing the original map to be used in the 2022 election.

Following the 2022 election, the Supreme Court ruled that the initial plan was illegal, as it violated the Second Amendment of the Voting Rights Act. Alabama has pushed back on this, arguing that two minority-majority districts would also be a racial gerrymander. Alabama was then allowed to make a new map but failed to create a second Black-majority district. The Court then stepped in, creating a temporary map to be used in the 2024 election with two Black-majority districts.

Currently, the State Legislature is figuring out its next steps. They are still awaiting the final decision from the Courts over whether their second drawn map was illegal. Regardless of the decision, it is almost certain that a new map will be utilized in the 2026 elections.

Objective: This analysis aims to determine whether there is evidence that Alabama racially gerrymandered its congressional districts in the 2022 plan.

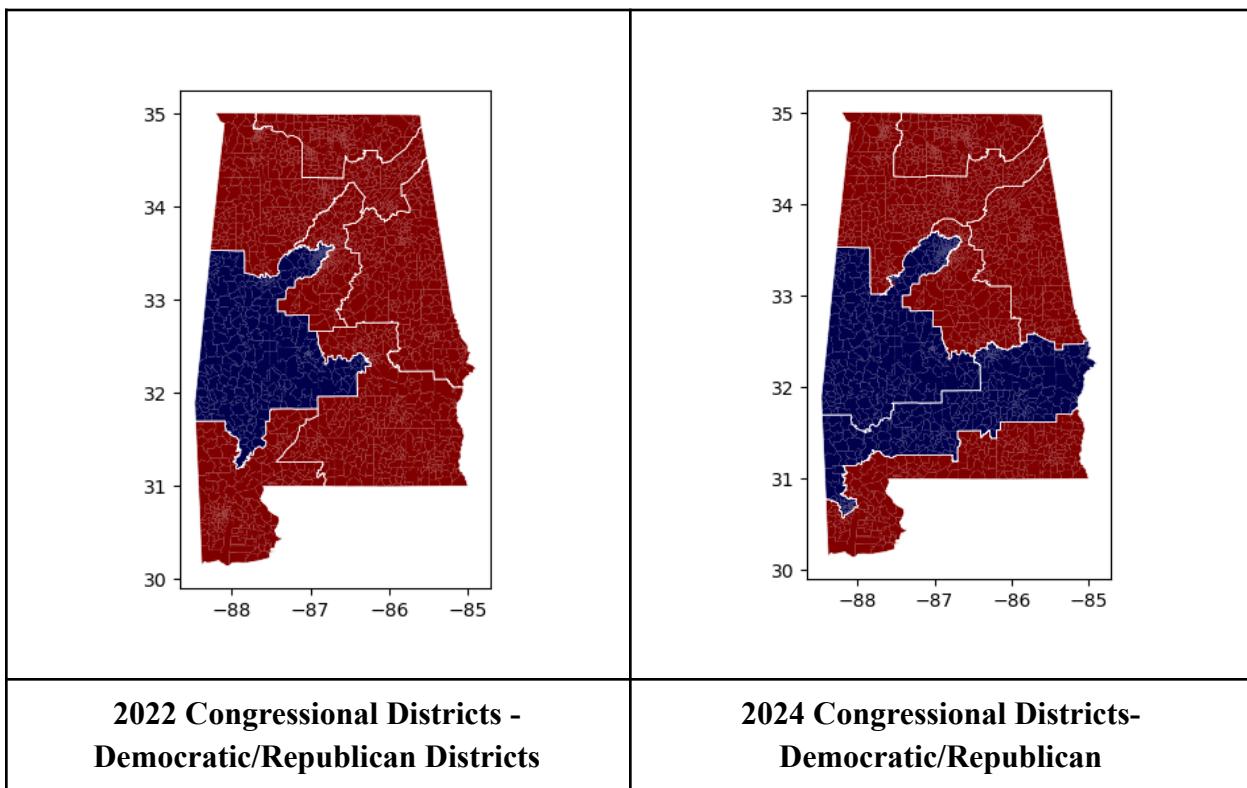
Data:

As detailed above, I focused on two different Congressional Districting Plans enacted by Alabama: the plan used before the 2022 election and the plan used in both the 2022 and 2024 elections.

I collected the precinct dataset from [Redistricting Data Hub](#), which had collected the precinct-level 2022 election results from the Alabama Secretary of State.

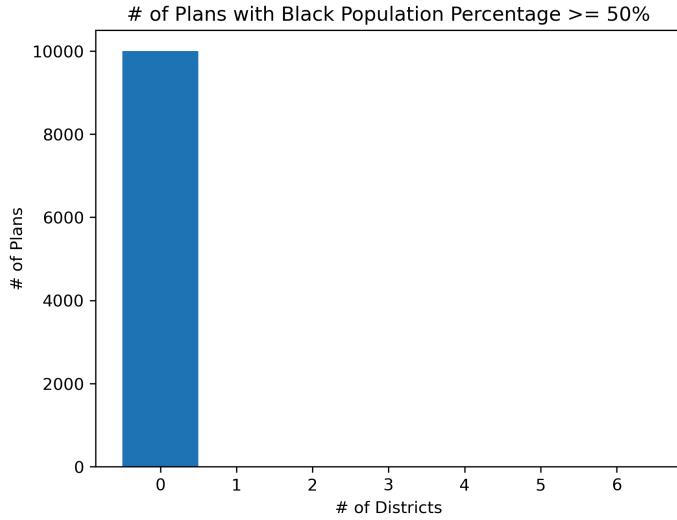
I then combined this precinct voting dataset with the two congressional districting plans. I found Shapefiles for each of the plans from the [Redistricting Data Hub](#).

After combining those shapefiles into a new GeoDataFrame, I combined it with the Census Data. The [Census Data](#), provided by the US Census Bureau, is in Block form. I first had to join the Census Data to a [Shapefile with Block to Precinct](#) matching (from the 2022 TIGER/Line Shapefiles Website), then aggregate the block census data up to the precinct level. Finally, I combine the aggregated precinct census data with the precinct voting and congressional districting data. This allowed me to have one Geodataframe with all the necessary information to conduct my analysis.



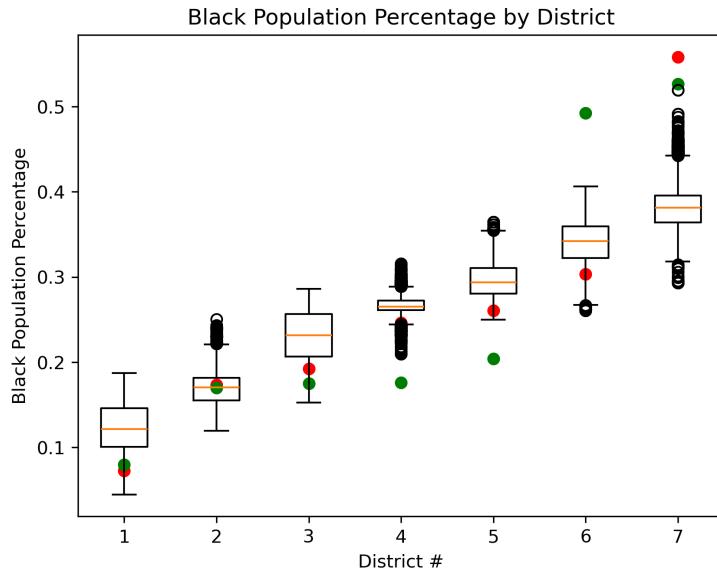
Analysis:

According to the Ensemble Analysis, 0 districts should have a black minority-majority (greater than 40%). I conducted a ReCom random walk from the original plan (for 10,000 and 20,000 steps), the adopted plan (for 10,000 steps), and a random plan (for 10,000 steps). All four of these had majority of plans with zero minority-majority Black districts.



Most Likely # of Black Minority-Majority Districts in Alabama, from a Random Plan

To examine this further, I also created a box-and-whiskers plot of the Black population percentage, which shows that having one black minority-majority district would be an outlier.



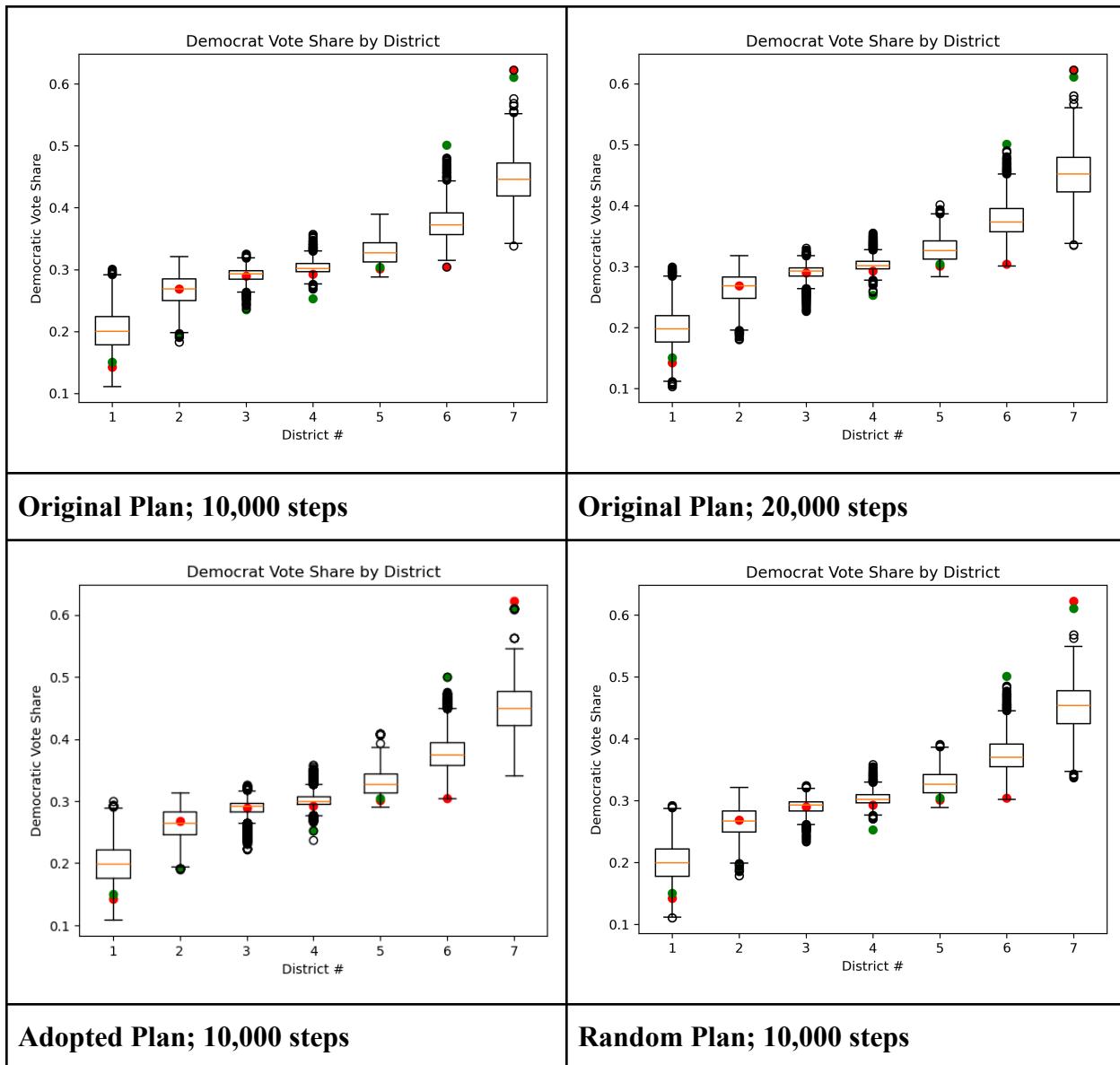
Percentage of Black People per District in Alabama, from a Random Plan (Red = 2022 Plan; Green = 2024 Plan)

Although this court case was regarding racial gerrymandering, I wanted to examine how a Markov Chain random walk on the map of Alabama would impact the number of Democratic districts. Every plan recommended 0 Democratic districts, with 1 also being a valid but unlikely choice. In the 2022 plan, there was one Democratic district. In the 2024 plan, this was increased to two Democratic districts. If we were to modify the 2024 election results based on the most

likely outcome of the ensemble, two Democratic districts would flip to Republican, thus losing two Democratic seats in the House.

Mixing Time:

I ran multiple different random walks, with various starting plans and running lengths, to ensure that our ensemble was completely mixed. For each random walk, I created a box-and-whiskers plot detailing the percentage of Democratic votes in each district. I have included the box-and-whiskers plot for all five runs. Because I got very similar results between all four, it concludes that the Markov Chain is close to stationary at 10,000 steps.



Limitations:

Although the most likely possibility in our ensemble is to have no minority-majority districts, this does not mean that having one is a sign of racial gerrymandering. As discussed above, one minority-majority district was also a possibility. Additionally, there may be inconsistencies in our data or how we create the ensemble that would reduce the likelihood of a minority-majority district occurring. Similarly as discussed in Florida and Louisiana, there is also the question (and ongoing debate) of whether a minority-majority district should be formed because it can be formed, or because it is the most likely occurrence.

Conclusion:

There is not enough evidence to suggest racial gerrymandering when considering the Ensemble Analysis, but our initial ensemble suggests that two minority-majority districts are not a common occurrence. When considering the change in plans from 2022 to 2024, we see a new minority-majority district formed.

For purposes of our analysis, we can conclude that creating a plan based on the ensemble would decrease the number of Democratic districts in Alabama by two.

Conclusion

To reiterate, in the actual 2024 election, the Republicans won 220 seats in the U.S. House of Representatives, and the Democrats won 215 seats.

According to our Ensemble Analysis, Democrats might have won the House in the 2024 election. The Republican party would have lost three seats, reducing their number of seats to 217. Similarly, The Democratic party would have gained three seats, increasing their number of seats to 218. Since a party needs at least 218 seats to hold the majority, the Democratic Party would have held the majority. However, this claim does rely on our ensemble analysis being entirely accurate, which is something that we can not prove.

State	Number of Congressional Districts	Change to 2024 Results based on Ensemble Analysis
Alabama	7	-2 D / +2 R
Georgia	14	+1 D / -1 R
Arkansas	4	+0 D / -0 R
Texas	38	+5 D / -5 R
Florida	28	-1 D / +1 R
Utah	4	+1 D / -1 R
Louisiana	6	-1 D / +1 R
South Carolina	7	-1 D / +1 R
North Carolina	14	+1 D / -1 R
Total Change		+3 D / -3 R

Change in 2024 U.S. House of Representatives elected based on Ensemble Analysis

In a future report, we would like to use the 2024 Election Data. Because we had to use 2020 and 2022 Election Data, there is some concern that voters' preferences have shifted in the past two/four years. Similarly, we had to use data from the 2020 Census, which assumes that people have not moved in the past four years. Although there is no easy way to accurately fix the problem with our Census data, we can fix our problem with the Voting Data by simply using 2024 data. At the time of this report, the 2024 Election data was not out for most of the nine states, and to ensure consistency across states we elected not to use this data.

Works Cited

For All States:

Census Data: <https://data.census.gov/>

Block-To-Precinct Data:

<https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2022&layergroup=Blocks+2020%29>

Election Information:

<https://www.theguardian.com/us-news/2024/dec/04/democrat-adam-gray-wins-california-house-election-against-republican-john-duarte>

Alabama:

Election Results:

<https://redistrictingdatahub.org/dataset/alabama-2022-general-election-precinct-level-results-and-boundaries/>

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