IEM 4013 Semester Project

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Team Name: The Tomorrow Team

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State: New Mexico

Executive Summary

To Whom It May Concern,

Our group, The Tomorrow Team, has been assigned to redistrict the state of New Mexico. Redistricting is necessary to ensure population equality and to prevent dilution of minority voting strength, as required by law. Prior to our redistricting, New Mexico had three congressional districts of uneven populations (2% deviation) and broken counties. Our team went in and created a model based on our research of how the state should be divided to ensure that the problems stated above were no more. We looked at three different models and compared the results and found that the model that minimized the perimeter was the best. Through our research we found that New Mexico was still assigned three districts, however the distribution that is best is very compact and contiguous. One district contains the northern portion of the state, another contains the southern portion, and the last contains the western side. Each district now has a balanced population with a deviation of 0.45%, and this way we are preventing the relocation and diminishing of minority and cultural groups.

Thank you so much for your consideration,

The Tomorrow Team

Introduction

New Mexico has had 3 congressional districts after both the 2010 and 2020 apportionments. After the 2010 redistricting, the state had one small district in the center of the state that contained the city of Albuquerque and two much larger districts, one that encompassed the southern ⅔ of the state and one that encompassed the northern ⅓ of the state. The population deviations were 5.6%, and the map met the criteria of equal in population, contiguity, and compactness as defined by state and federal law. The population bounds that would give a 1% deviation are 682,961 to 689,825. After the 2020 redistricting, the state's district around Albuquerque is slightly larger, and the southern district now contains the south and west part of the state, while the last district contains the north and east part of the state. It meets the same criteria as the 2010 map, but its population deviation is 0%. The population bounds that would give a 1% deviation are 702,311 to 709,370.

New Mexico Redistricting Criteria

<u>Federal Criteria</u>

- Required
    - Each federal district within a state must have about the same number of people.
    - Where discrimination plays or has played a significant role, and where voting is substantially polarized along racial or ethnic lines, look at electoral patterns and decide whether minorities already have proportionate electoral power.

- When considering race in drawing districts consider other factors in as well whether you are satisfying the Voting Rights Act or not.

➢ Prohibited

- Plans that dilute a protected minority's voting strength
- Drawing lines that set out to harm voters based on their race or ethnicity.
- Intentional discrimination (cracking, packing)

State Criteria

➢ Required

- Equal in population: total population that deviates plus or minus five percent from the ideal.
- Contiguity only to the extent possible: general principle that the constituents within a district should live as near to one another as practicable
- Preserve political subdivisions: keeps communities with common interests, concerns, and identities together in a single district, which enhances the democratic process by allowing elected officials to better understand and address the needs and issues of their constituents
- Compactness (contoured boundaries, dispersion, housing patterns) : all areas within a district should be physically adjacent
- Preserving communities of interest (group of people in a geographical area, such as a specific region or neighborhood, who have common political, social or economic interests)

➢ Prohibited

- Plans that dilute a protected minority's voting strength

- Unduly favoring (or disfavoring) a candidate or political party

➢ Allowed

- Preserve Cores of Prior Districts: efforts should be made to keep the central or core areas of the existing districts intact to prevent disruptive changes to the representation of communities and to ensure that constituents who were previously part of a district continue to be represented by the same or a similar district
- Avoid Pairing Incumbents: minimizes the likelihood of placing two or more incumbent elected officials (typically from the same political party) in the same district to prevent a scenario where two sitting officeholders have to run against each other for the same seat

➢ Encouraged

- To keep to political boundaries "to the extent practicable" but may bend when needed to uphold equal population.

https://redistricting.lls.edu/redistricting-101/where-are-the-lines-drawn/
https://ballotpedia.org/Redistricting
https://www.ncsl.org/redistricting-and-census/redistricting-criteria

Current Status/Problem Statement

New Mexico is currently made up of three congressional districts. Figure 1 contains the congressional districts as of 2022 and Figure 2 contains the congressional districts with county lines. As it is currently drawn, New Mexico has counties that are split up into different districts which is not optimal. Our goal is to come up with a new redistricting plan that satisfies all of the federal and state criteria.

Figure 1: Congressional Districts

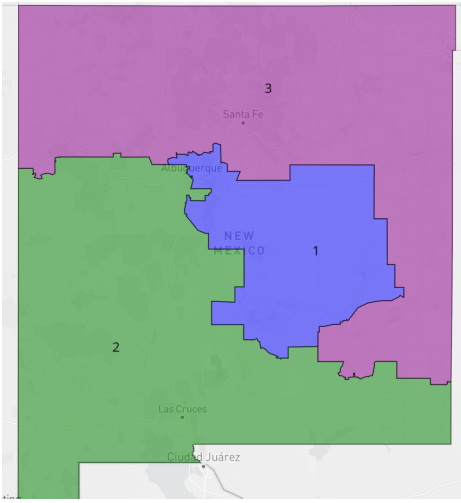
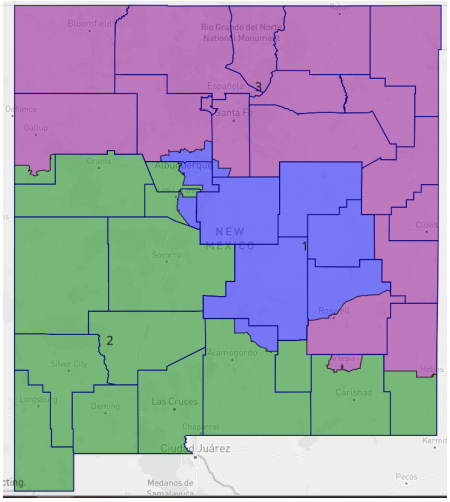


Figure 2: Congressional Districts with County lines



OR Model

Sets: C = the set of counties in New Mexico

Indices:

i = a county in New Mexico

j = a district in New Mexico

Parameters:

P_i = the population of county i

k = number of districts in New Mexico

L = lowest population allowed in a district

U = highest population allowed in a district

Variables:

x_{ij}= 1 county, i, is assigned to district j

0 otherwise

y_{ij} = 1 if edge $e \epsilon$ E is cut

0 otherwise

r_{ij}= root of county, i, assigned to district j

f_{ij} =flow of county, i, assigned to district j

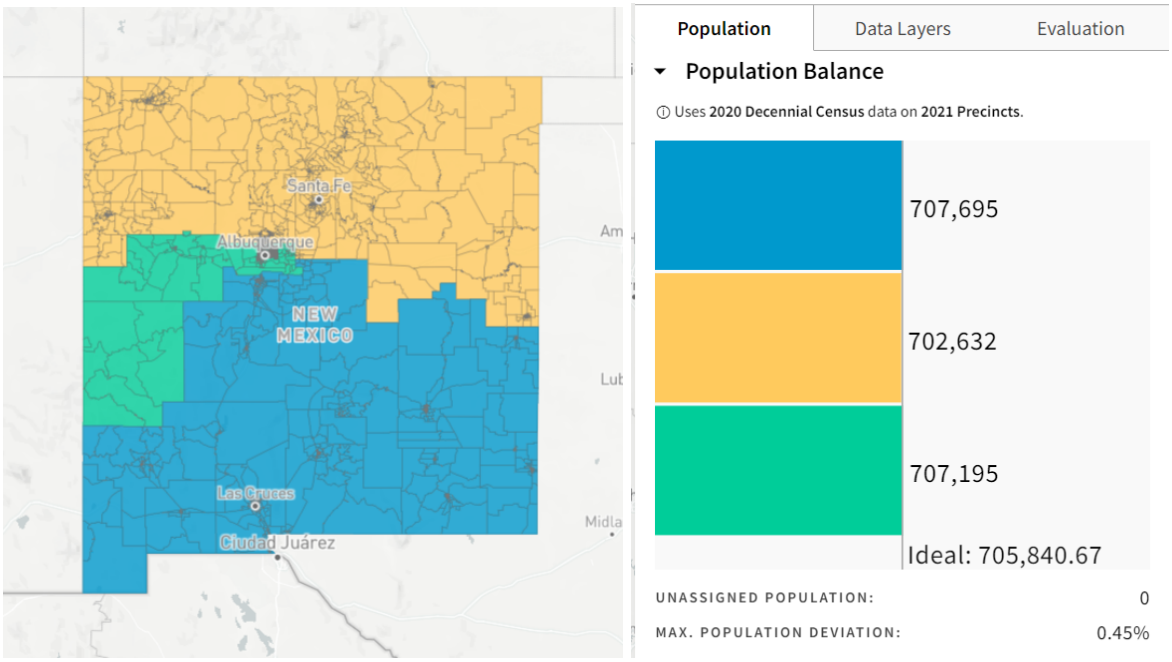
Minimize sum of weighted cut edges	**Min** $\Sigma_{e \epsilon E}\, y_e$
Make edge e **=** $\{u, v\}$ **cut when vertex u is assigned to district j**	**subject to:** $x_{uj} - x_{vj} \leq ye \;\; \forall e = \{u, v\} \epsilon E, \; \forall j \epsilon \{1,2, \dots, k\}$
Each vertex i **is** *assigned* **to only one district**	$\Sigma^{k}_{j=1}\, x_{ij} = 1 \qquad \forall i \epsilon V$
Population of each district between L and U	$L \leq \Sigma_{i \epsilon C}\, P_i \leq U \quad \forall j \epsilon \{1,2, \dots, k\}$
Every cut edge is either 0 or 1	$x_{ij} \epsilon \{0,1\} \qquad \forall i \epsilon V, \; \forall j \epsilon \{1,2, \dots, k\}$ $y_e \epsilon \{0,1\} \qquad \forall e \epsilon E$
Every district has only one root	$\Sigma_{i \epsilon V}\, r_{ij} = 1 \qquad \forall j \epsilon \{1,2, \dots, k\}$
Vertex $i \epsilon$**V cannot root to district j**	$r_{ij} \leq x_{ij} \qquad Vi \epsilon V, \; \forall j \epsilon \{1,2, \dots, k\}$
Make vertex i **consume flow when it is not a root**	$\Sigma_{u \epsilon N(i)} (f_{ui} - f_{iu}) \geq 1 - M \Sigma^{k}_{j=1}\, r_{ij} \quad \forall i \epsilon V$
Prevent flow across cut edges	$f_{ij} + f_{ji} \leq M(1 - ye) \quad \forall e = \{i, j\} \epsilon E$
Flow cannot be negative	$f_{ij}, f_{ji} \geq 0 \qquad \forall \{i,j\} \epsilon E$
Roots are binary	$r_{ij} \epsilon \{0,1\} \qquad \forall i \epsilon V, \; \forall j \epsilon \{1,2, \dots, k\}.$

Experiments

The computer the code was run on has a processing speed of 2.60 GHz and 16 GB of RAM. The code was written using Anaconda, Jupyter Notebook, Gurobi Optimizer 10.0.3, and Python.

Anaconda simplifies the process of managing and installing libraries and dependencies, Jupyter Notebook is used for interactive data analysis and visualization, Gurobi is a package that utilizes operations research principles to optimize problems efficiently, and Python is a programming language. The optimal solution is 13.397, which is representative of the minimum number of cut edges. The run time of the model to achieve the optimal solution was 0.31 seconds.

Plans and Maps



Evaluation

For the project, we ran three different models: one minimized the number of cut edges, one minimized the perimeter, and one that minimized the moment of inertia. This model, the

minimization of the perimeter, was the best when compared to the others that we tested. The new proposed redistricting map from our model meets the state and federal requirements about the population deviation, contiguity, compactness, and preserving prior district cores. The population deviation is extremely small at 0.45%, which is far below the state law of 5%. All three districts are contiguous and each county belongs to only one district, there are no broken up counties. As far as compactness goes, the three districts have reasonable shapes and each make up a certain part of the state. The first district contains the entire northern part of the state and the city of Santa Fe. The second district encompasses the whole southern part of the state and the city of Las Cruces. Lastly, the third district makes up Albuquerque and part of the western side of the state. It is a much smaller district because Albuquerque is the largest city in the state by a wide margin. The limitations of this plan are that it doesn't take into account the history of discrimination or where minority groups live. However, since we didn't intentionally try to gerrymander, pack, or crack districts it is unlikely to be present in the model. Those constraints would require a more advanced model and better computer to run it on. Overall, this model performed better across the board when compared to the other two models we tested. It had a small population deviation and made the most sense from a compactness point of view. Additionally, one of our team members is from New Mexico and understands the demographics of the state, and she confirmed that this model logically made the most sense.

Conclusion

The state of New Mexico needed to be redistricted, because as it currently stands the districts are oddly shaped, have over a 2% deviation, and contain broken up counties. While these issues are

not explicitly illegal, they are not optimal and should be fixed. We tested out three different models: one that minimized the number of cut edges, one that minimized the perimeter, and one that minimized the moment of inertia. Ultimately, the best model was the one that minimized the perimeter. It gave a population deviation of 0.45% and provided the best output in terms of compactness and contiguity. The only drawback we have identified is the lack of modeling on minority populations which is a requirement by law. However, it is difficult to quantify actions such as gerrymandering, cracking, packing, red lining, etc. with our limited skill set and computer function. Therefore, we recommend our model to the state of New Mexico.