A Spatial Look at Redistricting

The Political Process and Modifiable Areal Unit Problem

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Abstract

Section 5 preclearance under the Voting Rights Act and the debate surrounding its implementation require detailed demographic information about our communities. More informed debate on the legislation requires the skills and tools necessary for self-inquiry to be available to the voting public. This article illustrates one way to look at municipal redistricting with regard to minority representation and the law. The analysis shows how freely available data and statistical tools can be combined in a GIS to yield greater understanding of voter representation at the municipal level. Results indicate that Black and Hispanic communities, while still remaining relatively segregated, have begun to disperse within the City of San Antonio. This study provides encouraging evidence that sufficiently motivated community organizations, activists, and political campaigns can now investigate, first-hand, how votes are distributed within their local area.

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Introduction

Municipal re-apportionment is an issue which affects most Americans' lives. Few topics on political agendas are as salient as voting rights and representation. However, municipal representative districts generally receive less scrutiny due to the smaller population and area of these districts. Since the founding of the United States, representative democracy has been maintained through free elections where every voting-eligible citizen enjoys the same representative "voice". This is reaffirmed by the decision rendered in *Reynolds v. Sims* (1964). Birth, death, and migration patterns necessitate regular revision of representative districts for all levels of government. This reapportionment process is carried out with data from each new decennial census (U.S. Const. art. I, §2; 28 CFR §51.28(a)(4); San Antonio, Tex., Ordinance 47304 (26 Oct. 1976)). Recent advances in computational geography and, more specifically, GIS-assisted-redistricting can and will be used more often by opponents and practitioners of Gerrymandering. These advances have the benefit of creating "unprecedented" opportunities for realizing political and social values through the districting process (Eagles, Katz, & Mark, 1999). Unfortunately, they also present a possibility of producing thoroughly gerrymandered results that can still pass strict scrutiny (Young, 1988). In the press there are numerous stories featuring genetic algorithms (Wharton School of the University of Pennsylvania, 2011) and "automatic" redistricting. These new and exciting developments should be approached with caution and objectivity. New technology also implies a greater need for understanding historical districting patterns by which a benchmark may be established to aid in the evaluation of future redistricting proposals. By looking at local changes in segregation and representation since the 1965 Voting Rights Act (VRA) a fuller understanding of potential civil rights policy outcomes will hopefully result.

Even though parts of the VRA are still technically temporary legislation, Congress has continually renewed these provisions. Despite advances toward greater racial integration in households and the workplace, research shows racial segregation continues to undermine the welfare of Black Americans. (Massey & Denton, 1993) The significance of Black segregation is a problem felt at the local level by neighbors, family, and the local economy. Political boundaries, too, have durable and potent effects upon people's lives; the way minorities are grouped within those boundaries especially impacts their relationship with local government. "In America, congressional re-districting is thought to be the main way to protect minority groups from potentially tyrannous majorities. But it is local governments which have a more profound and direct effect upon minority groups." (Ford, 1997, p. 1368). Redistricting plans are highly consequential and almost guaranteed to spark controversy. (Eagles, Katz, & Mark, 1999)

This study seeks to highlight the general course of residential segregation in San Antonio since passage of the VRA. It is unclear how the VRA increases representation and solidarity among the Black community with respect to demographic changes like migration. This study hypothesizes the extent of Black racial segregation had declined in the City of San Antonio since the 1970 Census yet overall levels of Black segregation from White neighborhoods remain high. Census tract data is utilized here for practical reasons. Census data is widely available in numerous formats and multiple summary levels for a given area. It also is dataset upon which all reapportionment is conducted at the federal level (28 CFR §51.28(a)(4)). While the U.S. Department of Justice utilizes a specific Census dataset (PL94-171) designed for redistricting analysis, this study uses the more common tract boundaries and summary file counts as these are more commonly available. Reapportionment was a primary reason the census was introduced (Eagles, Katz, & Mark, 1999) and by using tract-level data - (re-summarized at the municipal representative level) this study hopes to further a general understanding of local-level apportionment patterns. Being able to rely on freely available datasets and logical analytical techniques should open this field of inquiry to novice and expert analysts alike. This is important if local municipalities are to continue improving their districting schemes in an era where greater public participation is demanded. Although, there is more policing of federal representative boundaries due to the greater number of interests involved, local political boundaries have direct effect on a location’s amenity profile coupled with fewer people who have a stake in recognizing or quantifying electoral bias.

GIS is one technology which allows individuals to measure intensity and extent of demographic phenomena. Residential segregation begets racial inequality, and, by itself, is not sufficient to identify interference vis-á-vis “one person one vote”. The mere knowledge of the presence of segregation does not explain the local dynamic within and between the minority and majority clusters. (Downey, 2003) These are all necessary aspects when establishing the context of a reapportionment scheme and they are aspects future generations will still need to consider no matter what direction our redistricting praxis takes.

Residential segregation, despite having dropped off the national agenda, continues despite many attempts to legislate it out of existence. Massey and Denton (1993) argue that few Americans appreciate the depth and degree to which segregation continues to impact Black America and most view segregation as an anachronism that is dwindling away on its own. There is clear evidence segregation levels have declined across the country. (Glaeser, 2008) These declines have just barely begun to erode the edifice of residential segregation. Due to the complex dimensions involved in understanding racial vote dilution, this study relies upon four main study areas: segregation, malapportionment, legislation, and technology.

Segregation

The current literature provides a robust debate about numerous facets of segregation, cause, extent, and effect at the local level. This study refers to residential, racial, and ethnic segregation sometimes alone sometimes in conjunction. To avoid confusion the more general “segregation” will be preferred unless some clarification is necessary.

In his book, *Cities, Agglomeration, and Spatial Equilibrium*, Edward Glaeser (2008) begins his theory of segregation with a discussion of what we know it is not. Racial segregation is not just a symptom of poor people living in cheap housing. He cites segregation rates much lower between rich and poor Americans than between Blacks from Whites. This echoes earlier findings by Douglas Massey and Nancy Denton's comprehensive work, *American Apartheid (*1993*)*, which was published 15 years earlier. They found segregation levels to remain stagnant for Blacks despite rising socioeconomic status and attribute this to the effect of white prejudice versus purely market forces.

While the market cannot be said to wholly cause segregation, the real estate market provides a useful litmus test with which to compare three competing theories of racial dynamics. These three theories of the cause of racial segregation are White decentralized racism, White centralized racism, and Black clannishness. (Glaeser, 2008) White decentralized racism refers to the segregation caused by an internal constraint on White choices (i.e., preference to live among one's own race). This could be due to what people often term racism but could reflect other factors such as shared types of consumption and social habits. There is much anecdotal evidence of this kind of segregation, where White Americans prefer to live among their own race despite espousing to favor integration. After a neighborhood tends toward integration it is favored more highly by Blacks than Whites. (Glaeser, 2008) (Massey & Denton, 1993) White centralized racism refers to the ability of the White majority to discourage Blacks from settling in their neighborhoods. There exists evidence for this kind of racism even today. Due to the perceived need to perpetuate some exclusively-White neighborhoods, discriminatory practices can dissuade even well-qualified buyers from racially exclusive areas. These practices are widespread and extend to renters and prospective home-buyers. (Massey & Denton, 1993) The third theory of segregation is that of Black decentralized clannishness. Black Americans' preference for racially-mixed neighborhoods may contribute to levels of segregation and we find segregation among most racial and ethnic minorities. But this theory, alone, cannot explain the persistence of Black segregation.

Given these three theories, the trajectory of the price differential facing White versus Black home-buyers can help us draw some conclusion as to which theory is at work in a given neighborhood. Under the condition of Blacks paying a premium over white housing, we expect to see barriers to Black mobility which is indicative of the Black preference or centralized White racism. This was indeed the case, especially during the 1940s. This price-effect has diminished over time and “essentially disappeared” after 1970. (Glaeser, 2008) Under the condition of White decentralized racism we expect to see Whites pay a premium for predominantly White neighborhoods. This pattern is observed more recently and appears to agree with most people’s current preconceptions. As segregation has moved from an overt policy to a decentralized phenomenon we see changes in housing prices that mirror this shift.

Levels of segregation have been measured over time beginning with early studies even before the 1940’s. In general, the period from 1890 to 1950 saw steady increases in Black segregation. Segregation rates leveled off between 1950 and 1970. After 1970 we begin to see a decline which continues through each decade to the present. (Farley & Frey, 1994) (Glaeser, 2008) Curiously, segregation of new immigrants has recently increased, opposing the trend in Blacks. It is hypothesized that this reflects avoidance of car-based suburbs among immigrant and poor populations. Despite the decline, the segregation of Blacks is unique in extent and effect from segregation of other minority groups. (Glaeser, 2008) (Massey & Denton, 1993)

Black segregation has numerous deleterious effects. First, segregating lower-income workers is said to preclude predominantly Black and low-income workers from employment in suburban firms. This is the so-called “Spatial Mismatch”. (O'Sullivan A. , 2009) This makes Black communities especially vulnerable to fluctuations in the local economy and concentrates poverty levels when times are toughest. During good times, Black Americans remain segregated despite increased earnings.

Integration is reserved for only the most educated Blacks. These factors create an ghetto environment replete with poor economic conditions, a deteriorating family culture, and inadequate educational opportunities. (Massey & Denton, 1993) This environment perverts social norms and negatively influences Black society and especially young children. In response to what Massey & Denton term a "harsh extremely disadvantaged environment," ghetto culture has a different set of behaviors, attitudes, and expectations from the rest of American society (1993, pg. 13). They argue these changes make segregation a persistent problem that allows a system of racial subordination to perpetuate.

Malapportionment

Malapportionment deals with the dilution of votes at the individual level; white Gerrymandering is often committed by groups against groups in the political sphere. Polsby and Popper identify at least three different types of gerrymandering: racial, remedial-racial, and collusive bipartisan gerrymandering (Polsby & Popper, 1991). Today, Gerrymander remains somewhat vague amidst the wholly political process of redistricting; use of malapportionment is usually reserved for legally unfair practices. Most commentators consider *Baker v. Carr* (1962) (which declared redistricting a justiciable cause) to be rightly decided while regarding claims of gerrymandering as suspect (Polsby & Popper, 1991). In either case a political bloc (usually with a small but significant majority) can exclude registered voters through its influence of the redistricting process. Even minority groups can secure re-election through gerrymandering. Thus, both sides stand to benefit from this sort of systemic abuse. This may explain why it is such a prevalent and costly fight. "In districting, legislators are fighting for their own political lives and that of their party, just as surely as in an election campaign, but with more durable results" (Polsby & Popper, 1991, p. 302). Finally, it is important to consider the effect of annexation on apportionment. Taken individually, most annexations have little measurable effect on urban minority populations. The aggregate effect from these annexations, however, can be significant over time (Baumle, Fossett, & Waren, 2008). This indicates the need for time-series analysis and highlights a complication. There exists no normative political consensus between the desire for subgroup integration (desegregation) and the desire for subgroup representation through political solidarity (Ford, 1997). It is believed the next-best outcome is minority representation roughly equivalent to total population percentage (Baumle, Fossett, & Waren, 2008).

Legislation

Race-based vote denial has a history in the U.S. going back into the 19th century. Beginning in the 1930's it came under attack. By the mid-1960s States were having to resort to increasingly subtle ways of keeping out the Black vote. These efforts were challenged in court one after the other in a judicial game of "whack-a-mole." (Clegg, 2013) The VRA of 1965 was designed to halt this case-by-case approach by authorizing the executive branch to implement a totally new regime to enforce minority voting rights at all levels of government.

The act restored suffrage to excluded Black voters in the South and later to other minority groups across the rest of the United States. It also gave the federal executive branch and Justice Department a very important charge. The VRA provided for election observers to participate in whatever numbers the President thought necessary. It banned literacy tests, poll taxes, and any action "under color of the law" that prevents lawful voters from being counted. The act has been renewed and amended multiple times; in 1970, 1974, 1982, and 2006. (Clegg, 2013) (The Schlager Group, 2008)

The VRA contains both permanent and special provisions (which require reenactment) for addressing unfair practices. The permanent provisions regulate the voting process nationwide. Section 2 is one of these provisions; it allows any citizen anywhere in the country to bring suit against the state for an existing unfair practice. (Baumle, Fossett, & Waren, 2008) The special provisions come with a sunset clause and are designed to attack specific discriminatory practices. These are found mainly in sections 4 through 9. Section 4 creates a triggering formula to identify which political subdivisions are subject to the special provisions. These jurisdictions are predominantly in the South but there are many exceptions. Most importantly, section 5 of the VRA froze all covered jurisdictions' election laws at the time of its enactment. If state or even municipal officials want to changed their laws or practices they require permission or 'preclearance' in the form of a summary judgment from the Justice Department's Civil Rights division and Attorney General or the Federal Circuit Court for the District of Columbia. The Court has said the 14th & 15th amendments only ban actions by states that have discriminatory purpose. The VRA forces courts to also consider if a policy change has discriminatory effect. (Clegg, 2013)

By most accounts the VRA is one of the most successful pieces of civil rights legislation. The legislation successfully ended the practice of disenfranchisement in its many forms across covered jurisdictions. It also provided activists tools to transform election law and procedure with their input. These benefits extended first to Blacks but were applied later to other minority groups. As evidence, I have reproduced a table from *Milestone Documents in American History* which highlights the effect of the VRA, Table 1. The VRA required federal involvement in matters previously reserved to the individual states. The forced most municipalities to change away from at-large elections and encouraged the creation of majority-minority districts. (The Schlager Group, 2008)

Year	# Significant Black Public Officials
1965	<100
1989	3,265 (9.8% of electorate)
2000	>5,000

Table 1

There are a litany of complaints that have been raised against the VRA and Section 5 in particular. It is argued that it insulates Republicans from minority voters and "inconvenient" issues while doing the same for Black incumbents. (Clegg, 2013) It also ensures that Blacks are the only group that stands to benefit from public expenditure in their neighborhoods. (Massey & Denton, 1993) Clegg (2013) cites objections to the intrusion by the federal government into what was originally the States' domain, the fact that the provisions are not really "temporary", and seemingly arbitrary decisions about coverage based on the 1965 benchmark. He lists specifically: 3 out of 5 New York Burroughs are covered, only some counties within Florida, North Carolina, and New York are covered, Texas but not Arkansas, Arizona but not New Mexico. (Clegg, 2013)

Decisions Relevant to Redistricting

The Voting Rights Act, as enacted in 1965, is not the only governing restriction on States' powers to amend their representative district boundaries. Several other court decisions and one congressional amendment affect the redistricting process (see Table 2. They must be considered as a whole in order to provide guidance of what constitutes a permissible change under Section 5.

Case or Law	Year	Effect
Reynolds v. Sims	1964	equal protection clause of the U.S. Constitution requires one person's vote be worth as much as another – outlawed dilution of vote
Allen v. State Board of Elections	1969	extended VRA to vote dilution; even minor changes from benchmark require preclearance
Voting Rights Act as Amended	1982	protection of vote dilution through redistricting, changes in the electoral system, and annexation; any reduction in minority voting strength is forbidden regardless of state's interest
Thornburg v. Gingles	1986	established standard to test claims of vote dilution
Shaw v. Reno	1993	solely race-based classification denies citizens equal opportunity to polls

Table 2

Also pertinent to our study is Justice Stevens' dissent in the Shaw ruling where he specifically states there is no constitutional requirement that districts be drawn in compact shapes. (Soller, 1994)

Evaluation Criteria

The 'Basic Standard'; whether the submitted change has the purpose or will have the effect of denying or abridging the right to vote on account of race, color, or membership in a language minority group", is specified in 28 CFR §51.52 (1999). Redistricting factors for consideration are governed under §51.59, special attention should be paid to paragraphs

b) "The extent to which minority voting strength is reduced by the proposed redistricting.

c) "The Extent to which minority concentrations are fragmented among different districts."

[Cracking]

d) "The Extent to which minorities are over concentrated in one or more districts."

[Packing] and,

e) "The extent to which the plan departs from objective redistricting criteria set by the submitting jurisdiction, ignores other relevant factors such as compactness and contiguity, or displays a configuration that inexplicably disregards available natural or artificial boundaries." [emphasis added]

In their study *GIS and Redistricting*, Eagles et. al. list these criteria present in any redistricting problem:

- Population equality,
- Representation of minority groups,
- Geographic compactness and contiguity,

- Respect for the boundaries of other political units at different spatial scales,
- Continuity with extant boundaries,
- And (of course) partisan advantage.

Population equality is currently the most widely acknowledged criterion across all levels of government. Equinumerosity (as it is sometimes called) has its roots in the U.S. Supreme Court. The *Reynolds v. Sims* and *Wesberry v. Sanders* (both 1964) holdings found that all districts must have approximately equal populations. This has evolved to become the primary constitutional test for apportionment in light of the “one person one vote” precedent established by *Baker v. Carr* (1962). But equinumerosity is but one consideration at play with regard to the Voting Rights Act and similar legislation. Polsby and Popper give the example where a political party could designate one district as a “gimme” (to paraphrase) while negotiating boundaries which only need to establish a slim majority in the remaining districts in order to ensure victory at the polls (1991). This approach is so common as to have garnered the name “packing” referring to the attempt to gather as many similar voters as possible into the fewest number of districts given a population distribution. Because of existing jurisprudence, equinumerosity has been established as the primary constitutional test for districting plans.

Representation of minority groups has also been included as an evaluative criterion for building representative districts. Representation of minority groups is mentioned in §2 of the Voting Rights Act, 1982 amendment. Section 2 prohibits re-districting or other practices which have the effect of diluting the vote of minority groups. It is now generally understood that districts should be drawn to include a majority of members of minority groups whenever they could be drawn. Eagles et. al. also state this change has diminished the importance of other criteria since the early 1990’s when it was first truly put into practice, creating over 24 new majority-minority congressional districts in the process (1999) at the expense of other evaluative criteria.

The two effects tests mentioned are the retrogression test and the effects test. These two criteria apply to different actions taken by governments at different times. The governing body is required to redistrict in a way to prevent retrogression of minority voting power or the diminution of position of the members of any racial or language group with respect to electoral franchise. (Snare, 2001)(28 CFR §51.54(a)) This retrogression is against the current legal benchmark. The effects test is evoked through Section 2 and simply looks for the presence or absence of racial vote dilution. (Baumle, Fossett, & Waren, 2008) The benchmark for this test differs and is set to the voting strength roughly proportionate to the size of the minority group. These differing decision criteria, benchmark year and minority size, create inconsistency for courts and for the public. Yet even different criteria apply when the change is an annexation not a shared boundary. Furthermore, the VRA gives the DOJ no option but to object to any proposed change due to failure of the effects test. There is also no change for rebuttal from the state. (Clegg, 2013) Finally, recently election outcomes are relevant to the decision of whether or not an action constitutes a violation of the VRA's many provision.

While population percentage and minority group representation measure aspects concerning voter distribution the dual criteria of geographic compactness and contiguity both measure the district geometry. These criteria are what generally come to mind when one hears the term gerrymandering. Sinewy or serpentine districts appear to cut from one side of a county to the other. Polsby & Popper (1991) and Young (1988) both devote considerable attention to this topic. Polsby et. al. tell us contiguity is a "rudimentary notion of 'place'" and this generally common sense idea is largely ignored in the academic literature (p. 330). They go on to note the Supreme Court has never overtly stated a district must be contiguous but most states have some form of contiguity requirement. In their views contiguity is crucial and without it, equinumerosity is rendered mute. Similarly, without compactness, contiguity is irrelevant. This is mainly due to what is termed *topology*. Basically, a contiguous district that is not required to be compact can meander and roam across a map to subsume voters of a desired demographic. While Polsby & Popper make a powerful argument for compactness, Young (1988) makes a convincing argument that existing formal measures utilized by the states are inadequate and may have significant negative effects. He states compactness should be avoided or at least not operationalized via statute but rather interpreted in court with respect to context. This is a valid point, physical geography sometimes makes non-compact districts inevitable (Azavea, 2006). The Justice Department does enforce contiguity and compactness under (28 CFR §51.59(f), 1999) although without a formal decision rule. Eagles et. al. also include: "respect for the boundaries of other political units at different spatial scales, continuity with previous district boundaries, and (of course) partisan advantage" in their list of evaluative criteria for districting. These final three criteria will not be examined in this report. Finally, Baumle et. al. recognize that §5 of the VRA lacks a uniform effects test possessing one test for annexations, one for realignment of existing boundaries, and yet another specified in §2. This variation, they state, creates both legal and policy problems.

GIS

Our GIS references come mainly from the spatial statistics literature. David O'Sullivan and David Unwin present a through survey of the current state of the art of geographic information analysis. They list four related categories each of which are often labeled 'spatial analysis' (in order of complexity): spatial data manipulation, spatial data analysis, spatial statistical analysis, and spatial modeling. This report concentrates heavily on the first two categories and future study will also include spatial statistical analysis. There are two significant issues that are peculiar to spatially oriented data.

Spatial autocorrelation **(SA)**

SA implies that data from locations in close proximity are more likely to be similar than data from locations farther away. This seems intuitive and it should. Most spatial relationships in nature exhibit positive spatial autocorrelation so we don't think about it too much. In fact, O'Sullivan and

Unwin state that if SA were not commonplace, geography would be rendered irrelevant (O'Sullivan & Unwin, 2003). They state it is this *non*-random distribution which makes geography worth considering. Hence, this "bug" ends up being more of a feature if you know how to deal with its existence. Still, the authors of *Geographic Information Analysis* state SA is the greatest impediment to the application of conventional statistics on spatial datasets. They state that redundancy is inherent in spatial data and this invalidates the numerous diagnostic statistics with which we are familiar that presuppose a random distribution of observations.

The Modifiable Areal Unit Problem **(MAUP)**

The MAUP is another significant hurdle in spatial analysis and O'Sullivan and Unwin devote considerable attention to this topic. The MAUP exists when using aggregation units which are arbitrary with respect to the phenomena under investigation. This can produce misleading results and even lead to conflicting conclusions based on an investigator's choice of aggregation level. Unfortunately the MAUP is still not completely understood. We do know that it is composed of effects related to scale of analysis and aggregation. The MAUP persists in multiple summary levels and has the effect of strengthening regression and other relationships. "The practical implications of MAUP are immense for almost all decision-making processes involving GIS technology, since the now ready availability of detailed but still aggregated maps could easily see policy focusing on issues and problems which might look very different if the aggregation scheme used were to be changed (O'Sullivan & Unwin, 2003, p. 32)" All this implies choice of scale is a significant determinant of investigation findings. For the purposes of investigating possible disenfranchisement it is important to note correlation coefficients between -1 and 1 are obtainable for the same data given the proper aggregation level. O'Sullivan and Unwin suggest picking an aggregation scheme that maximizes the relationship strength between the two datasets.

Another consideration, outside the realm of spatial statistics, the ecological fallacy. This is another critical factor in this study. Much like the MAUP, the ecological fallacy implies that statistical relationships may change when we look at subdivisions of summarized data. Since municipal representative districts and census tracts do not always share boundaries there will be some modification of feature geometry to reconcile their boundaries. This change in geometry must be compensated for in the census counts affected by a modified tract boundary.

Difficulties in Evaluation

Before we begin with a discussion of our method, a summary of some difficulties noted in the literature is in order. First, Baumle et. al. indicate there exists significant difficulty in obtaining accurate population data and structuring it for longitudinal analysis. Population data is most accurately gleaned from the decennial census. But it often requires significant amounts of pre-processing before census data will yield useful information. The counting of minority sub-groups also presents a challenge. Latinos are generally undercounted and this makes it difficult to know the fraction of the Latino population which is eligible to vote. A similar dynamic exists for Blacks who have relatively high rates of incarceration and thus are disenfranchised by the state. Even the operational definitions of racial and ethnic subgroups have evolved within the census since the enactment of the VRA (Revisions to the Standards for the Classification, 62 Fed. Reg. 58782 (Oct. 30, 1997); U.S. Census Bureau, 2000; Peters & MacDonald, 2004, p. 95). Thus even after considerable advances in the past three decades there are still difficulties when comparing groups across multiple census periods.

The joint effect of the rulings in *Thornburg* and *Shaw* have created a “minefield” of legal requirements. (Snare, 2001) Districts must recognize sufficiently large and compact racial populations in Sections 2 and 5 of the VRA according to *Thornburg*. But after *Shaw* they cannot use race or Hispanic status as the *predominant* factor in drawing district boundaries. These districts must be created utilizing traditional redistricting criteria to the greatest extent possible. Presumeaby this is where compactness might fit in.

Hypotheses

The working hypotheses for the study are: 1) The extent of residential segregation in the City of San Antonio has declined in the time since enactment of the Voting Rights Act and 2) levels of Black segregation from White neighborhoods remain high. These hypotheses are supported by research showing an overall trend in decreasing levels of residential segregation since the 1970s and yet see Black segregation as the key factor in the perpetuation of Black poverty. (Glaeser, 2008) (Massey & Denton, 1993)

Prior research was carried out and determined tract-level demographic data could be transformed to municipal district levels of aggregation. This is important since appropriate geographic census summary levels did not exist when the VRA was passed, were only proposed in the 1990s, and were not provided by the City of San Antonio until the 2000 census (13 U.S.C. §141(c)). This necessitates repurposing alternative census divisions into a configuration suitable for time-series analysis. The appropriateness of this approach is still debated in the literature (Mitchell, 1999; Allen, 2009).

Method

Two phases were identified within the analysis process. These phases are common to many analysis workflows and will be described as the data Extract Transform & Load (ETL) process and the subsequent spatial analysis of the prepared data. It is often the case that the ETL process consumes more resources and time than the actual analysis and this study proved to be no different.

Data ETL

The ETL processes developed for this study comprise most of the work necessary in the calculation and tabulation of relevant statistics. The main requirements for this analysis included identifying suitable data sources, operationalization of racial and ethnic classifications, and transforming the raw data into a format suitable for input into standard geoprocessing tools. Geographic redistricting of representative districts at the municipal level is covered under §5 of the VRA (Political Subunits - 28 CFR §51.6, 1999). The Attorney General (or Federal District Court of Columbia) utilizes various measures to evaluate an action submitted for declaratory judgment. (Baumle, Fossett, & Waren, 2008) To conduct their work, the Department of Justice Census and redistricting committees generally rely on redistricting-specific population data provided by the U.S. Census Bureau under order of U.S. PL94-171 which is specifically targeted at redistricting support. (U.S. Census Bureau, 2011) This program was not designed to directly support municipal-level redistricting but does make the early-access dataset available to local officials in charge of redistricting. Due to the inclusion of the 1970 observation period, we rely instead on population counts from the census summary files.

Tracts-level data were extracted from the National Historical GIS (NHGIS) database and filtered to isolate Bexar country based on its Federal Information Processing Standard (FIPS) code – ‘48029’. These data were available in a comma-delimited text file. The text file was imported into an ESRI ArcGIS file geodatabase and subsequently joined to their respective tract boundaries which were procured from the NHGIS (1970 and 1990) or ESRI/U.S. Census Bureau (Environmental Systems Research Institute, 2010).

Municipal district boundaries were available from the City of San Antonio via their city clerk’s and GIS websites. City-council representative district boundary files for the 1990 and 1970 observations were inferred and manually digitized using their then-enforceable map and statutory records. City-council district features were available from the GIS website for the 2000 observational period and were imported directly from the provided feature classes. The individual district boundaries were then used as the spatial selection extent for the extracted Bexar County census tracts. In ArcGIS this is accomplished through the 'Select by Location' tool.

Data characteristics

There were several characteristics of the data that had to be defined and modified before any analysis could proceed. These dimensions established the population counts, racial and ethnic categories, comparability, and precision for the ensuing analysis. Since population data are not summarized at the municipal-district level some method of adjustment was needed for each population sub-group and 100% summary. This procedure is described in further detail under the next section.

racial classification

Racial classification was based upon self-identification with the race or races with which people most closely identify. For instance, the 1970 census question dealing with race provided these categories for the State of Texas: White; Negro or Black; Indian (American); Japanese; Chinese; Filipino; Hawaiian; Korean; and Other (specify). (U.S. Census Bureau, 1996) Clearly, these categories reflect socio-political constructs and are not scientific categories. Furthermore these categories reflect, both, racial and national origins. (U.S. Census Bureau, 2000a) Officially, the current census racial categories are specified in the OMB's Statistical Policy Directive No. 15. These categories are subject to change over time to reflect changing conceptions of racial identification. (62 FR 36874 – 36946)

The changing definition for the Black racial category utilized by the census reflects the fluid nature of what is considered appropriate and accurate by self-identifying members of a community. The 1970 census defines "Negro and other races" as those persons who self-identified as "Negro or Black" and also includes those who indicated under "other race" a written entry which "should" be included as

“Negro or Black”. (U.S. Census Bureau, 1996) The 1990, “Black or Negro” category includes persons self-identifying as: Black or Negro; or included write-in responses to the “some other race” category of African American, Afro-American, Black Puerto Rican, Jamaican, Nigerian, West Indian, or Haitian. (U.S. Census Bureau, 1991) And, finally, in 2000 the “Black or African American” racial category included: Black, African Am., or Negro; African American; Afro American; Kenyan; Nigerian; Haitian; or persons having origins in any of the Black racial groups of Africa. (U.S. Census Bureau, 2000a)

The White racial category has undergone similar, albeit less drastic, changes over time. In 1970 White also included persons who indicated the “other race” categories and furnished written entries that “should correctly be classified as White.” (U.S. Census Bureau, 1996) By 1990, this other race condition was changed to include write-in entries such as: Canadian, German, Italian, Lebanese, Near Easterner, Arab, or Polish. (U.S. Census Bureau, 1991) And in 2000, it changed yet again to include: origins in any of the original people of Europe, the Middle East, or North Africa; Irish, German, Italian, Lebanese, Near Easterner, Arab, or Polish. (U.S. Census Bureau, 2000a)

Hispanic classification

“Hispanic” as defined here and in the census as an ethnic categorization separate from the racial and national categories included under Black and White. Because of this, Hispanic identifies people who may self-identify with any race. Because of this, any tabulation including White, Black, and Hispanic categories does not represent a true comparison of the component parts of the 100% population count. For the 2000 census, 90% of all Hispanic respondents indicated either White alone (48% of Hispanic respondents) or “some other race” alone (42 %) under their answer for the question of race. Less than 4% of the Hispanic population also self-identified as Black or African American alone or some kind of Native American. (U.S. Census Bureau, 2000b)

The 1970 census was the first to expand the Puerto Rican category to reflect more members of the Hispanics community. In 1970 these “Spanish-American populations” were defined differently for various parts of the country. In Texas, Spanish-American include those who report Spanish as their “mother tongue” as well as those bearing a surname included on a list of 8,000 Spanish Surnames. (U.S. Census Bureau, 1996 pg. 97) The 1990 “Mexican, Puerto Rican, or Cuban” category included persons with these respective country-origins as well as origins in: Spain; and the Spanish-speaking countries of Central or Southern American, or the Dominican Republic.” (U.S. Census Bureau, 1991) And by 2000, “Spanish/Hispanic/Latino” included these specific categories in conjunction with: Mexican; Mexican Am.; Chicano; Puerto Rican; Cuban; and those who indicate they are “other Spanish/Hispanic/Latino” such as those included in the 1990 definition.

comparability

It is important to note the the new two-question format for race and hispanic labels and changing methods for dealing with the “other race” category. These discrepancies make direct comparison between data from different censuses impossible and leads to vastly different counts for the White and Other categories when looking at the San Antonio population. Furthermore, our data are reaggregated at the municipal district level. These changes indicate that only broad trends should be discerned from trends extending beyond one or two ten-year census periods.

precision

Census tracts from the NHGIS were originally provided in the Albers Equal Area projection. All census files were later transformed into the State Plane Coordinate System (Texas South Central Zone FIPS 42024). The state plane coordinate system is often relied on by municipalities due to its small degree of distortion at the scales utilized in this study (less than 50 miles from end to end). The selection of the U.S. State Plane Coordinate System was predicated upon the reliance of the City of San Antonio on this projection and the need to rely on a common coordinate system for all reference data. The transformation process introduces some degree of 'drift' in the modified data but this drift is effectively constant for each census tract. The two conic projections provide for a relatively straightforward coordinate transformation.

The level of precision for the population counts is assumed to be lower than the tract-level population data since they have been re-aggregated at the municipal district level. Also, manually digitized or inferred features often do not share precise boundaries. Slivers, gaps, and other artifacts (multi-part features, e.g.) were removed in the topology cleanup step which alters boundaries in a minimal way in order to enforce certain logic rules. Also, map features present in archive resources are not directly observable without historic aerial imagery. In the absence of this imagery, digitization requires a fair amount of intuition and subtle observation on the part of the investigator.

Transformations

The following transformations were performed to reconcile collected data with the needs of the spatial analysis tools. They have the net effects of conforming and re-tabulating census counts to accurately portray the demographic and geographic aspects of municipal district boundaries. These transformations should not be confused with the geographic coordinate transformation initially used during import of the NHGIS census tract boundaries, and refer to manipulations performed after the initial data import procedures.

digitize and subsume features

The first step in data preparation was to create GIS features which represented historic municipal district boundaries. The available San Antonio city records identified voter precincts for the decade effective 1 March, 1974; and consisted of a non-georeferenced map image from the City of San Antonio Clerk's online archive (City of San Antonio, Office of the City Clerk, 2011). Once that decade's voter precincts were digitized, a data column was added to the feature class and attributed with the appropriate district number as specified in City of San Antonio Ordinance 47304 (1976). The final historic boundaries were output from the ArcGIS Dissolve tool which subsumed all election precincts with identical district boundary values into a single feature representing the municipal city council district boundary. The merge tool's input and output were both stored in the geodatabase, and are illustrated in Figure 1

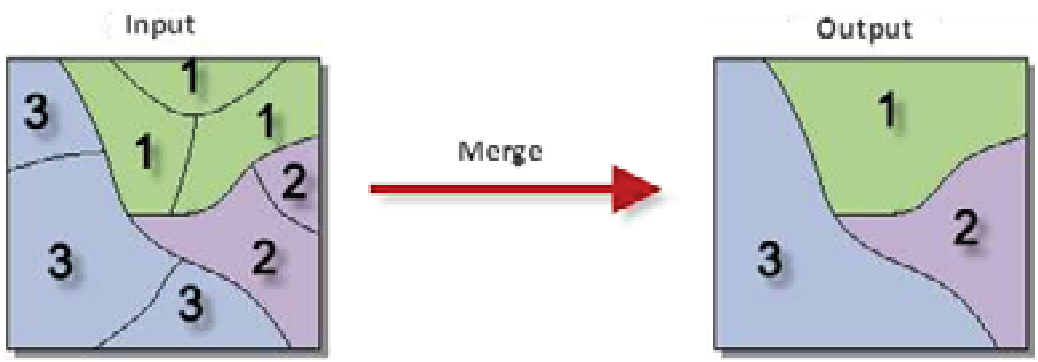

Figure 1, reproduced from ArcGIS 10.1 user documentation

The district boundaries for the next observation year (1990) were less complicated to construct. Available city records delineated council districts in image format which obviated the task of election precinct delineation and allowed direct inference and digitization of the 1990 municipal boundaries. District boundaries for the year 2000 were available for download directly from the City of San Antonio GIS Department website.

topology cleanup

File geodatabases have the capability to enforce topology rules to maintain the logical integrity of the federal and municipal boundaries. This includes enforcing a consistent planar surface which improves data quality (Figure 2a & b - applied to the municipal layers) and modeling boundary relationships (Figure 2c – shows where census and municipal boundaries align). Artifacts of creation like multipart features and gaps can be avoided with topologies which aid overall in the data compilation process. The three main rules enforced for this study were: must not overlap, must not have gaps, and area boundary must be covered by boundary of. In each case, a cluster size of 5 feet and consistently ranking the federal boundaries higher than the digitized features ensured that errors would be minimized in the next step of preparation, the intersect tool.

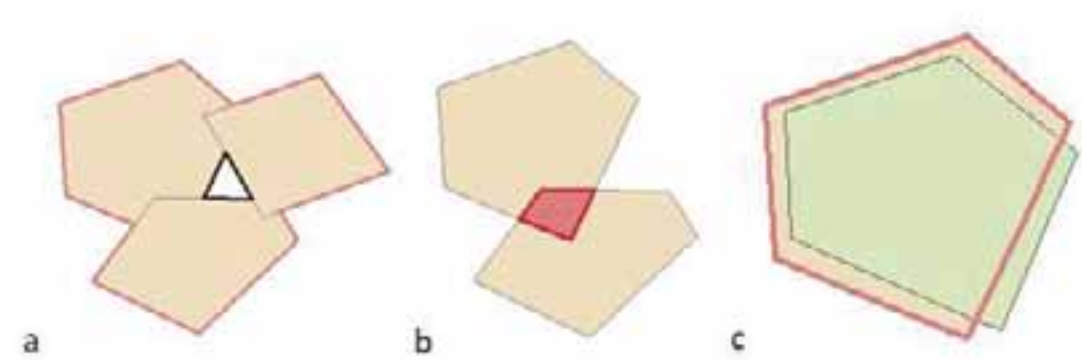

Figure 2 a) must not have gaps b) must not overlap c) area boundary must be covered by

intersect tracts

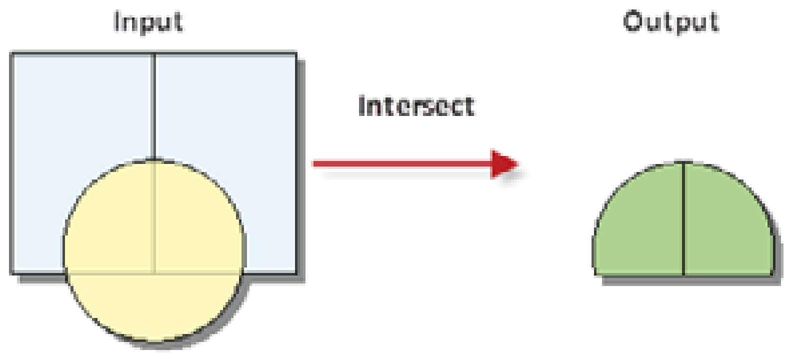

Figure 3 Geometric intersection

Utilizing the ArcGIS intersect tool, Bexar County tract features were "intersected" with the cleaned City Council district polygons yielding district-bounded census tracts conforming to the jurisdictional limit of the City of San Antonio and its constituent representative districts. Geometric intersection is illustrated in Figure 3. The output features were then attributed with the appropriate representative district number by use of the spatial join and feature calculator tools. After the geographic boundaries were subdivided, the next step was adjusting the population counts accordingly.

numerical adjustment

Since the intersect tool only operates on feature geometry (and, indirectly, the auto-generated [Shape_Length] and [Shape_Area] fields), it is necessary to adjust the adjoining census data in the attached feature data table to the same degree. Before running the intersect tool a new data field was created called [old_area] of type 'Double'; its value was calculated to equal the [Shape_Area] value. After the intersect process another field was created named [Chop_Ratio]. This new field, also of type 'Double', was calculated to equal the following expression.

```
[Chop_Ratio] = [Shape_Area] / [old_area]
```

The [Chop_Ratio] value indicates the ratio of a feature's current area to its pre-intersection area. Then population counts are reduced by multiplying by this ratio to yield an adjusted count relative to the degree to which a feature has been divided. At this point, new fields can be created to contain the adjusted population values or the old values may be overwritten. It is not necessary to cast the adjusted population values as ‘Double’ since this data type is only used here briefly for purposes of the preceding floating-point division. ArcMap should take care of the rounding back to integer values or can be instructed to perform this rounding on the fly for labeling or other symbology.

Note we assume there exists a homogeneous racial distribution *within* each census tract. For our purposes at this scale this assumption may have an important bearing on our results. (Peters & MacDonald, 2004) (Mitchell, 1999)Are non-uniformities in racial distribution located in the same areas where a tract has been ‘intersected’ (i.e., broken apart along a city representative boundary by the intersect tool). Clearly some non-uniformity is guaranteed. (Anselin, 1995) But census values have already been aggregated and it would be impossible to investigate further without comparing against blocks or block groups for the same area. Figure 4 Adjusted population is shown with the original census count indicated in parentheses. Each color’s adjusted values sum to the original tract’s population count. depicts this situation with five census tracts taken from the year 2000 observation data. Each color represents the original census tract and the first number is the adjusted population count for the new district-bounded census tract.

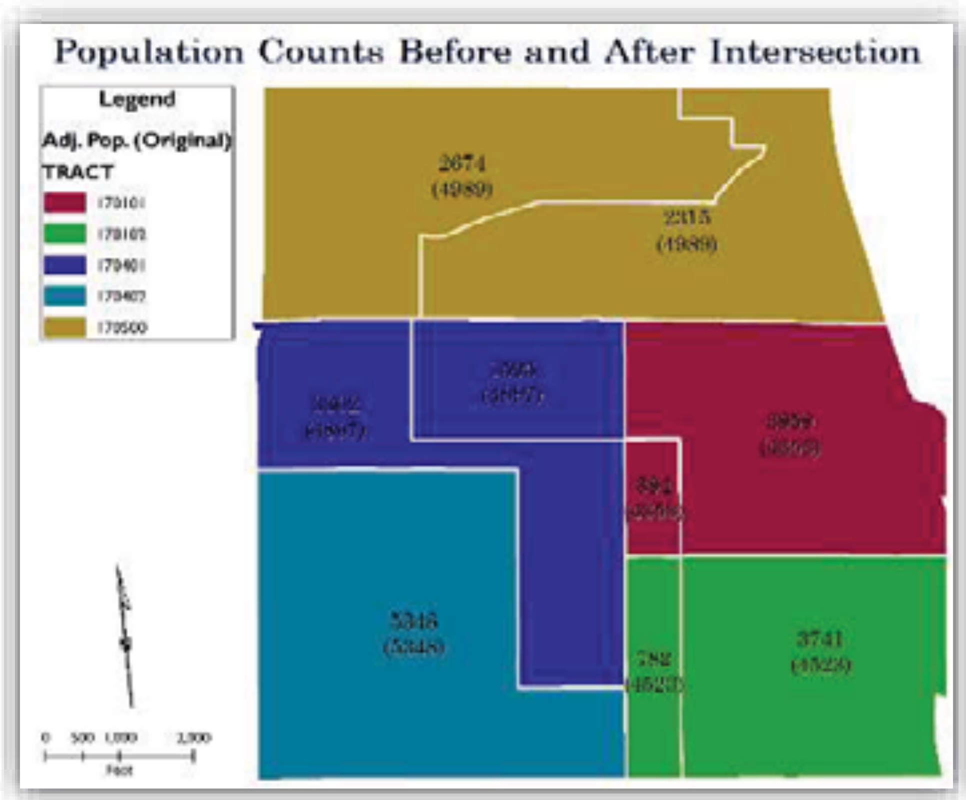

Figure 4 Adjusted population is shown with the original census count indicated in parentheses. Each color's adjusted values sum to the original tract's population count.

Spatial Analysis

With the data cleaned and imported, our ETL processes is complete. The analysis procedures were mainly taken and adapted from Taeuber and Taeuber (1965) but exploratory analysis and available tools also effect which analyses and visualizations were fruitful. Identifying vote dilution required describing the neighborhoods and the segregation present in the periods throughout the study.

Neighborhoods

Our neighborhoods or units of analyses are the municipal representative districts in San Antonio. Populations were classified by race and ethnicity for each of the council districts. These counts are used later to populate tables, graphs, and maps. We also summarize each neighborhood by looking at the number of minority residents and the relative percentage of white or non-white population. (Taeuber & Taeuber, 1965)

Segregation

With our neighborhoods clearly defined through city-council boundaries and the population sub-groups defined by OMB as implemented by the census bureau, it is necessary to identify clustering of the sub-groups at the city council district level. Like Taeuber & Taeuber, we also utilize a dissimilarity index in order to measure segregation and its variation from one representative district to another. This similarity index can be described as the share of people of one minority group who would need to move areas in order to make the minority distribution equal over the study area. (Glaeser, 2008) Unlike their earlier study, *Negroes in Cities,* this study utilizes a spatial variant of the dissimilarity index. This dissimilarity index variant, D(s), was developed to take into account proximity and area of neighborhoods, not just their racial variation. (Wong, 2003) This is in contrast to the use of Moran's *I* or the local variant of Moran's *I*. This other popular spatial metric measures clustering or a local component of clustering. The usage of D(s) in this study reflects the common usage of the dissimilarity index for the study of racial segregation and a preference for measuring difference versus similarity. In this way, our method differs from that of Cohn and Jackman (2011).

$$D(s) = D - \frac{1}{2}\sum_{i}\sum_{j} w_{ij}\left|z_i - z_j\right| \times \frac{1/2\left[(P_i/A_i) + (P_j/A_j)\right]}{\max(P/A)}$$

The dissimilarity index runs from 0 (complete homogeneity) to 1 (complete segregation). One consequence of reliance on the D(s) is our inability to directly compare indices between differing geographic summary levels. The dissimilarity index is highly dependent on the size of area being calculated relative to the sample universe. Measured at the individual level, the index is always 1. If we were to use the entire city as our neighborhood *and* study area the index would be 0. (Glaeser, 2008) The ratio of neighborhood area to total study area has a direct impact on the calculated index value for a given neighborhood. This is another reason the use of the 'Double' data type is necessary since the D(s) statistic is entirely dependent upon an accurate measurement of a neighborhood's area and perimeter.

It is this dependence upon neighborhood definition that Glaeser (2008) notes as a primary consideration when using the dissimilarity index. But, Glaeser adds, there are also several advantages of the index over other measures. He notes that if the number of minority members goes up equally in all parts of the city, the index will remain the same. If the neighborhood is subdivided equally, the index will not be affected unless the subdivision occurs along racial lines. The usage of the D(s) also allows us to test for the effect of the modifiable areal unit problem. By comparing similar geographic areas' D(s) values for varying neighborhood sizes we can note if our selection of neighborhood is heavily influence by the scale of observation. (Cohn & Jackman, 2011) A method of comparing global statistics with their local-variant components is suggested as an appropriate method of exploratory analysis. (Anselin, 1995)

There is some discrepancy as to whether a dissimilarity index calculated off an exogenously defined neighborhood can be considered truly spatial in nature. (Cohn & Jackman, 2011) A truly spatial measure should be calculated off a neighborhood of 1 person. However, drawing this kind of distinction misses the point. Any measure of segregation – a nebulous and complex concept that is based up on shifting concepts of racial identity – would seem to introduce multiple layers of abstraction. (Taeuber &

Taeuber, 1965) For instance, if data were available at the individual level (this is disallowed by the census and numerous federal statutes to protect privacy) then where do we place an individual in space? If one's primary residence seems logical, than what about those residing in multi-family housing? What about children of shared-custody and those who are homeless or temporarily displaced? Is it necessary to identify which side of a large group-home someone sleeps? This argument seems largely irrelevant when considered against the backdrop of segregation. We ignore these complications and provide the data for the reader to asses in light of context and applicability.

Our model, as implemented, was calibrated to limit computations to individual district-bounded census tracts and select up to five additional neighborhoods within a 5 mile search radius. Any additional neighborhoods (here – district-bounded census tracts) beyond the 5 mile buffer or beyond the fifth neighbor within that radius (searching clock-wise from 0 degrees North) would be excluded from the computation. These tool parameters, 5 mile search radius and 5 neighbor maximum, were arrived at by visual examination of the resultant plots of discrimination indices. As it turns out, most city-council districts were approximately 10 miles across so this subdivision into 5 mile buffers for each tract allow us to roughly capture variation at the council district scale (a sampling rate of half the measured frequency). The D(s) may be calculated for multiple minority groups simultaneously. The population definitions, however, suggest a simpler approach. Since the Black, Hispanic, and White counts do not sum to the 100% population count it was decided to model each minority separately versus it's inverse component. In practice, it required comparing Black versus non-Black and Hispanic versus non-Hispanic populations as opposed to looking at the dissimilarity between Black, White, and Hispanic distributions. This yielded 9 plots of dissimilarity for the study area; three population groups taken over three observation periods.

Each plot was symbolized identically with regard to the dissimilarity value. These symbology definitions were utilized for all plots to show change based upon the 1970 observation. The classes for symbolizing were first calculated based upon the Black/non-Black plot for the 1970 census. Since our Hypothesis indicates this is probably the most segregated regime we expect to see declining rates of segregation for other populations and census years.

Results

The observation, noted in Taeuber & Taeuber (1965), that Blacks tend to reside closer to the city center than Whites holds true in the case of San Antonio. The following map in Figure 5 depicts the presence of different population groups within the city over time. We note a small area of Black presence in the Eastern part of the city with a larger area of Hispanic predominance in the Southwest quadrant. The White population is distributed evenly across the study extent with an anomalous absence in the Hispanic areas during the 1990 census. This may reflect the shifting classification of Spanish Language peoples from the 1970 period into the Hispanic category which was introduced in the 1980 census. This would yield an overly diffuse distribution of Whites in the 1970 plot (most Hispanics were categorized as White in the 1970 census). This could also indicate some error in the data processing phase.

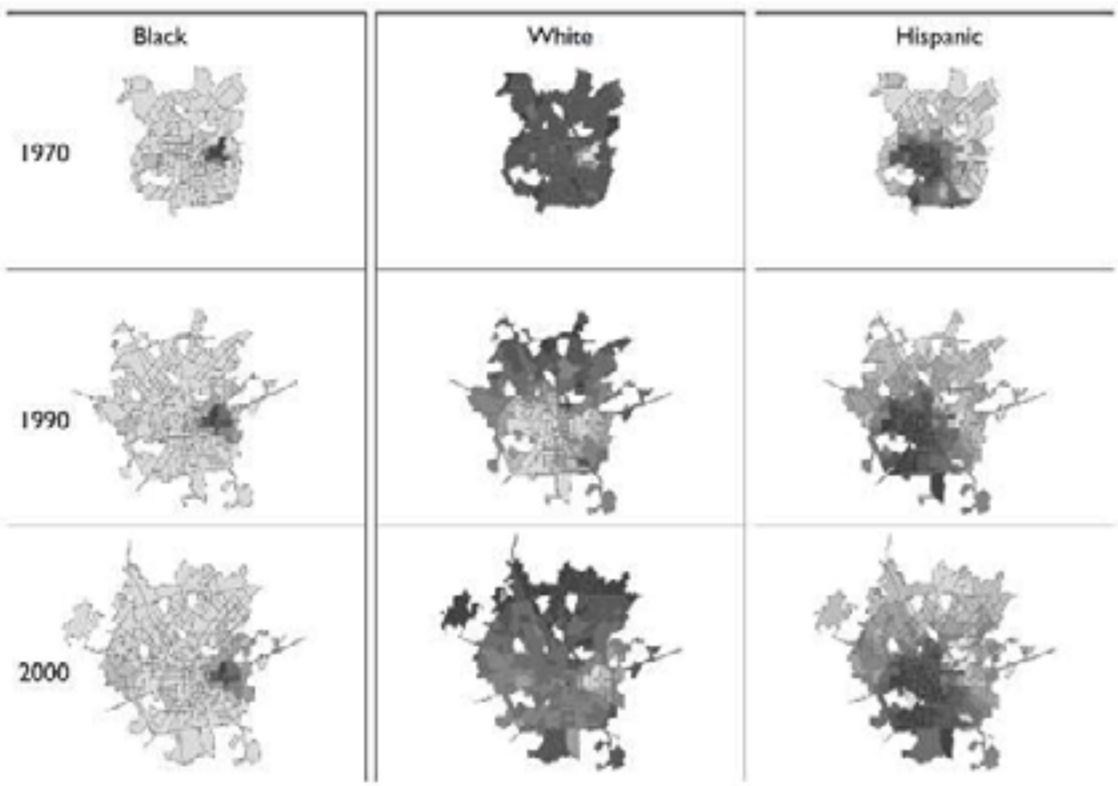

Figure 5 Population Distributions for San Antonio by race or ethnicity and year.

These maps only show the areas where certain populations are present. They are not enough to indicate how these population groups relate to each other in terms of size. Figure 6 shows city-wide population counts per group over the three observation periods. San Antonio appears to be a majority Hispanic community throughout the study period. Blacks have remained the minority group over the same time period. The proportion of population from one group to another seems to be relatively constant after considering the changing definition of Hispanic / Spanish Language groups between 1970 and 1990.

The two plots, Figure 5 & Figure 6, show moderate clustering of population groups which have attenuated over time. Utilizing the dissimilarity index offers a finer-grained view of how dissimilar the various representative districts are from one another.

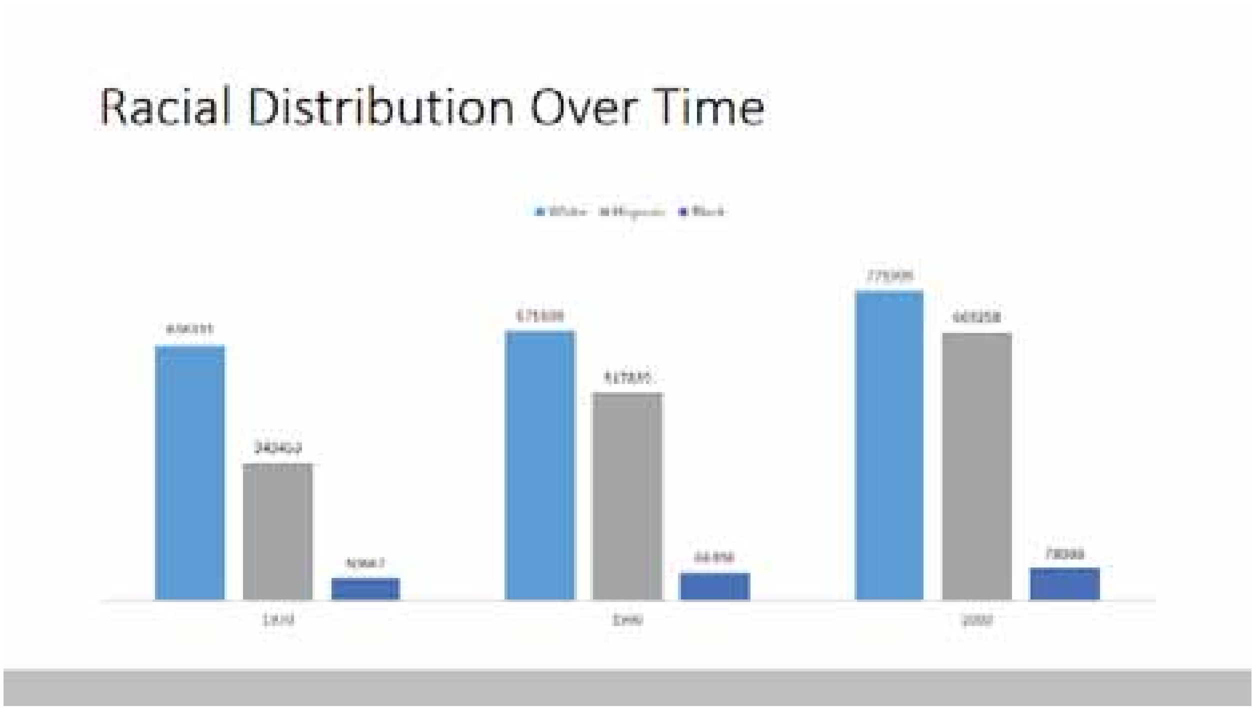

Figure 6

Comparing their dissimilarity index illustrates striking trends among the representative districts. From Figure 7 it is clear district 2 has an anomalous index value as compared to Black populations in other districts. This value, although declining, is still significantly higher than other districts throughout the study period. This also holds true when comparing Black dissimilarity indices with the values for the Hispanic population shown in Figure 8.

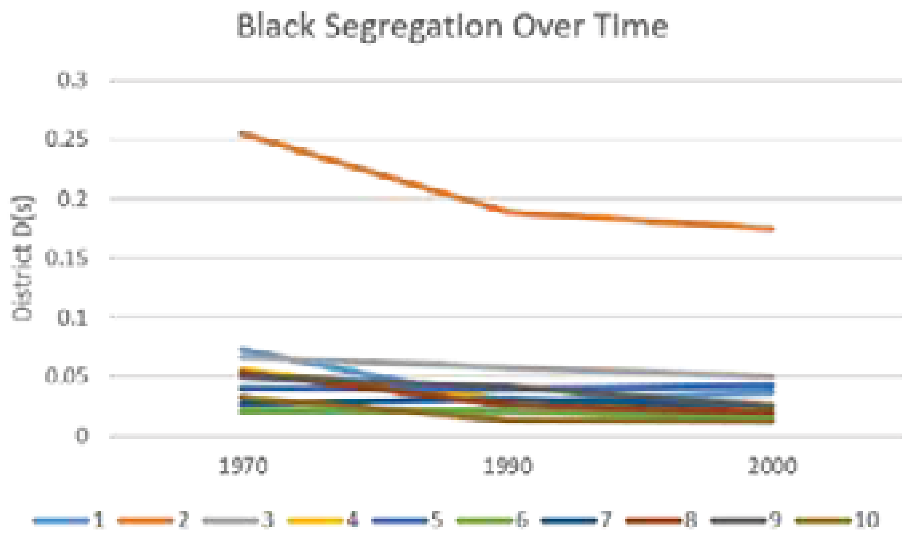

Figure 7

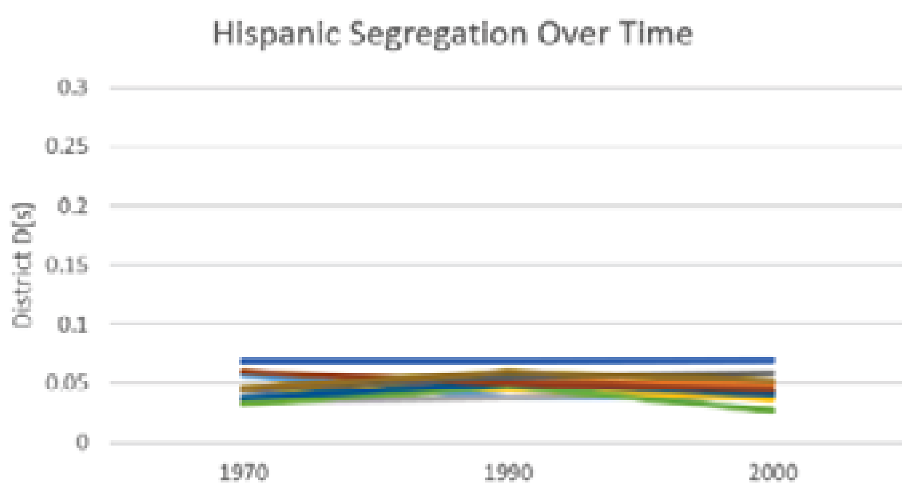

Figure 8

The results of analysis of the local dissimilarity indices show a baseline segregation index value centered on the D(s) = .05 level with district 2 a clear outlier. At the 1970 observation, nearly 3 out of 4 San Antonio Blacks resided in district 2 yet, as a bloc, they did not constitute a majority – accounting for 43% of the district's population. When coupled with the historically low levels of Black voter-registration and turnout, this shows that even highly segregated groups can still be at odds with the majority under council-district representation regimes which are favored by the Department of Justice. By 2000, less than 2 out of every 5 Blacks resided in district 2 – or about 30% of the districts' population. High levels of dissimilarity coupled with only a plurality of the district 2 vote point to a segregation pattern noted by Massey and Denton as prevalent in the Southern United States. They say that, unlike Northern segregation patters, Southern segregation is more patchwork reflecting the employment of Blacks in White households as domestic workers. (Massey & Denton, 1993) Over the same time period, the share of Blacks within the city as a whole grew from 8% to 10.1%. These statistics, coupled with our maps of dissimilarity indices (see Appendix) show the highly localized nature of Black settlement and also indicate a declining level of segregation among the Black and Hispanic communities. This is congruent with what is known about the MAUP and how it relates to segregated groups; but it is impossible to say without utilizing smaller census summary levels to confirm (which precludes identifying specific racial and ethnic categories).

Over-reliance on the D(s) statistic is to be avoided. Since dissimilarity indices were calculated one district-bounded census tract at a time, their values are highly dependent on calculation parameters like the number of neighbors to include and the search radius used to select those neighbors. For instance, by aggregating the dissimilarity indices for each racial group, a fundamentally different scenario is portrayed in Figure 9

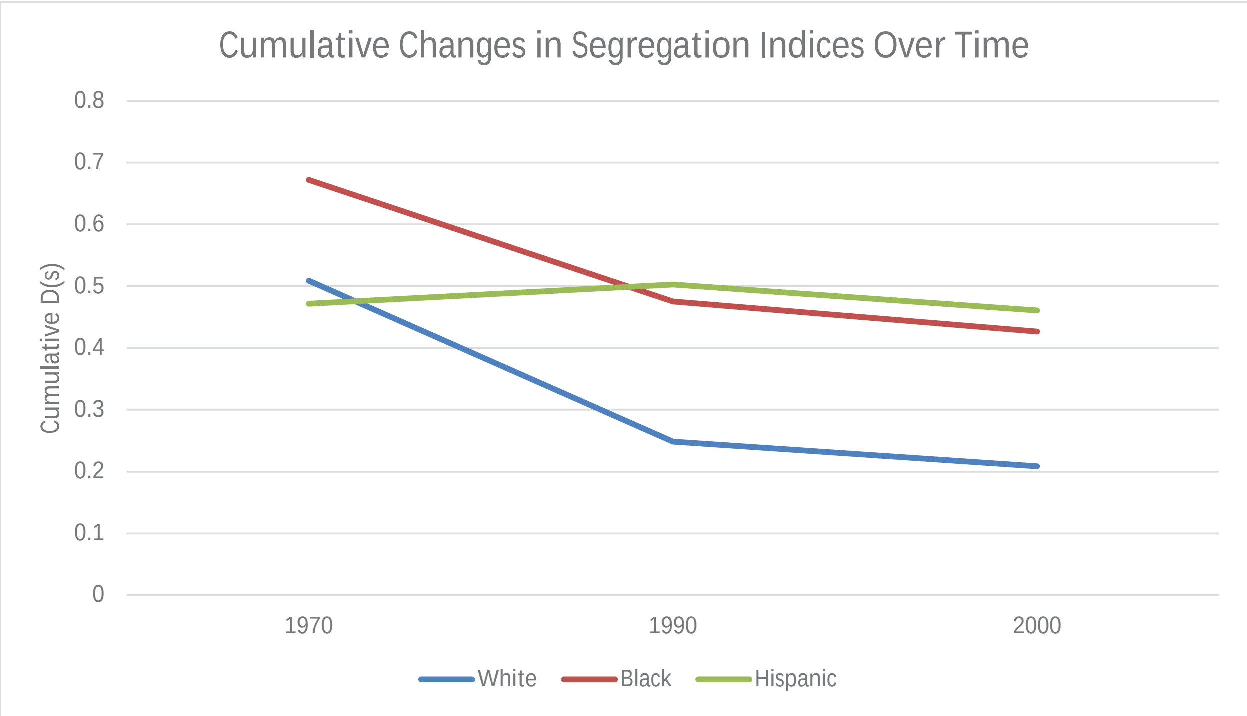

Figure 9 Segregation indices aggregated by racial or ethnic type.

The values shown in Figure 9 show greater dissimilarity in the Hispanic community distribution than in the Black community yet the maps seem to indicate the opposite.

Discussion

Since enactment of the Voting Rights Act, the city of San Antonio has seen a decline in segregation among Black, White, and Hispanic populations. Aggregate levels of segregation seem to indicate high levels of segregation exist for Blacks and Hispanics with the Black community exhibiting more localized segregation than the Hispanic community. At the district-level, D(s) statistics and population plots show high-levels of Black residential segregation concentrated in city representative district 2. But when aggregated at the city level, it seems that the Hispanic community is the most segregated population. The reason for this could reside in the relative size of the Hispanic population versus the Black population. And since neighborhoods were excluded beyond the 5 mile search radius, our plot of the D(s) statistic may be optimized to highlight only certain patterns of settlement. Conflicting results could also be due to the scale selected and sensitivity to complications brought on by the MAUP. Further study needs to characterize racial and ethnic distribution at a larger scale (smaller units) than is currently possible with census tracts. Better understanding the role analysis parameters (i.e., search radius and number of included neighbors) play in highlighting specific segregation patterns is also required. Finally, without looking at voter registration patterns and considering age distributions within population sub-categories it is hard to say what effect demographic trends exert in the representative arena. For these reasons, analysis of this kind is best conducted by community members who are attuned to the specific concerns that are relevant to certain municipalities. Perhaps the dissimilarity index is only useful for aggregate analysis; and its related statistic, the isolation index, is better suited to neighborhood-level comparison. Further research should focus on the observational effect of tool selection and calculation parameters. These experimental settings can paint different pictures of a community due to their interaction with phenomena like the MAUP and effects of edge neighborhoods versus interior neighborhoods within the study area. To do this, finer grained demographic data needs to be obtained or superior methods of data correction should be utilized.

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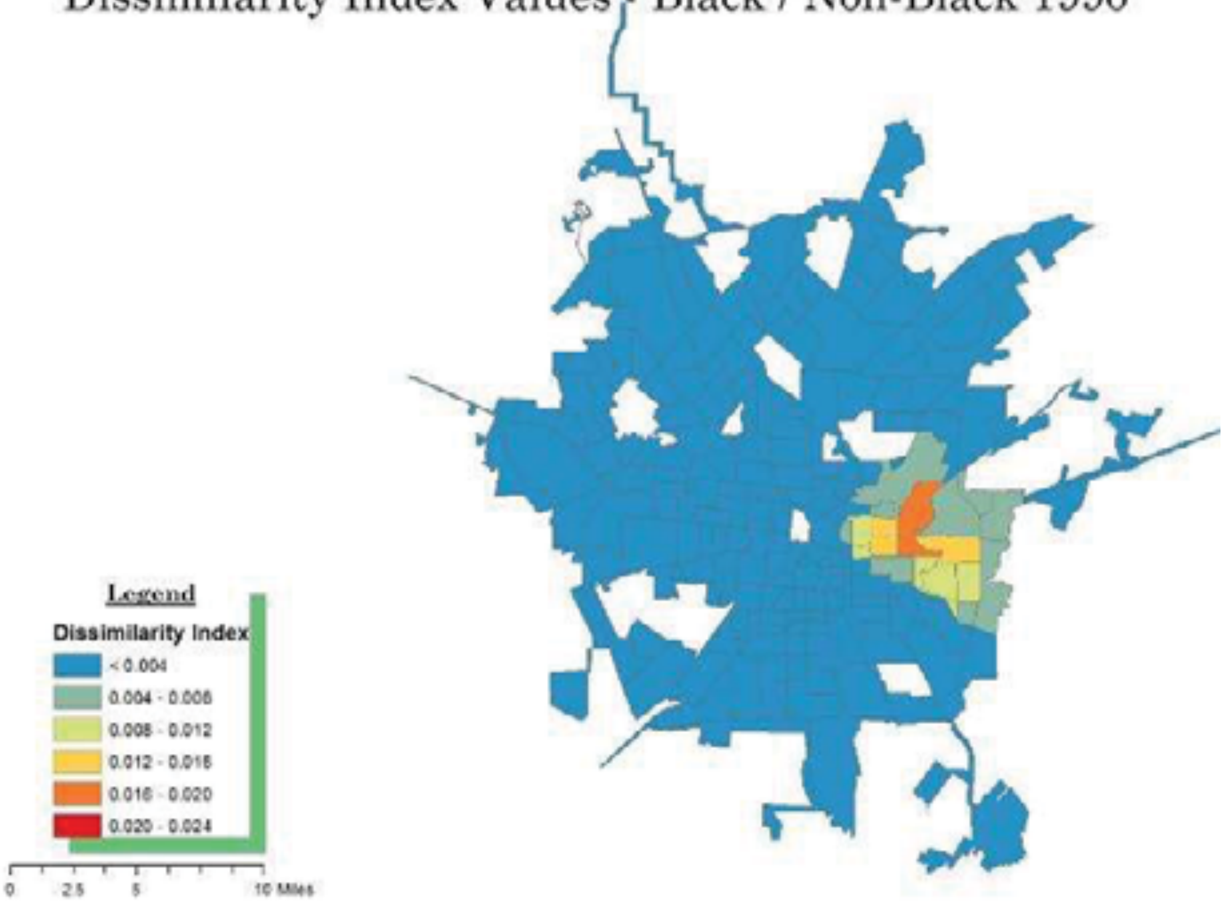
Appendix

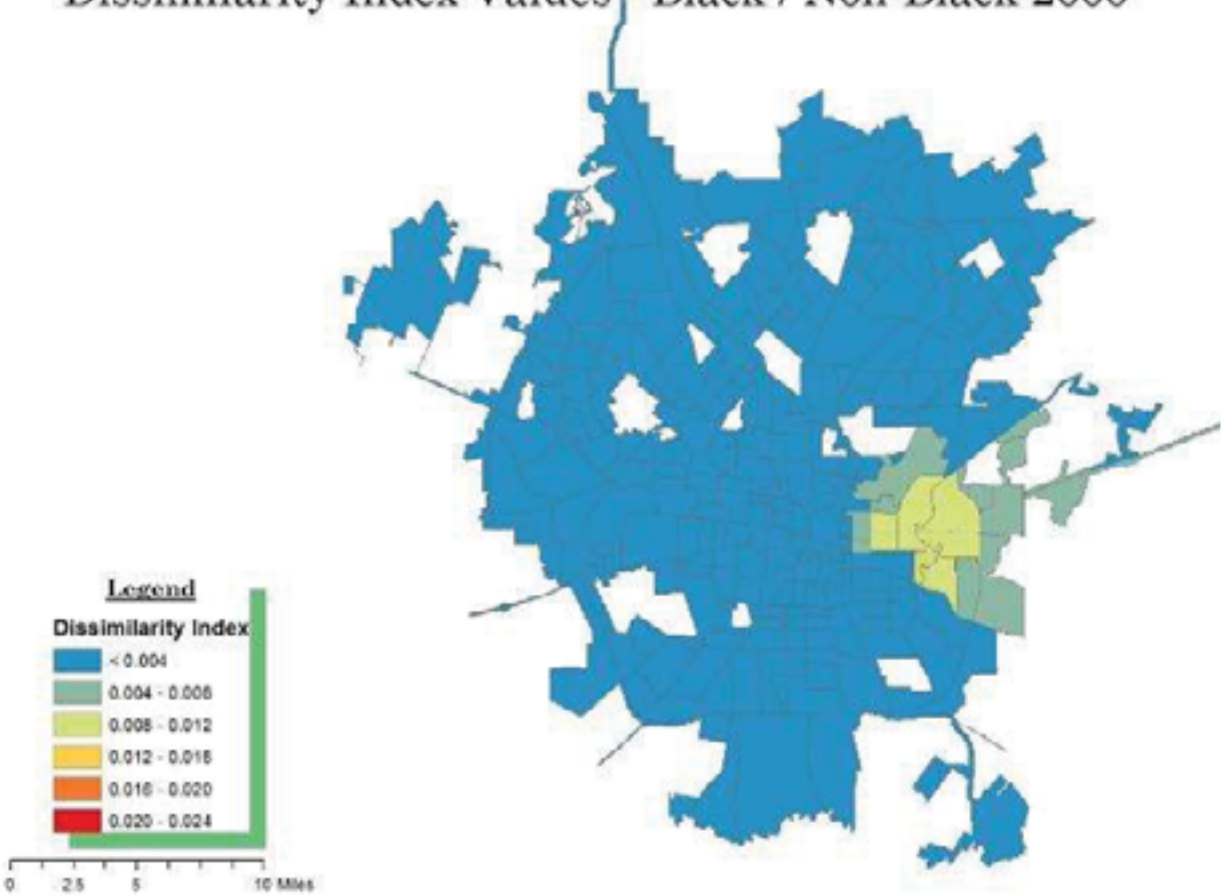
Plots represent values of the D(s) statistic calculated for each census or district-bounded census tract. Scale is held constant and colors represent the same values throughout the series.

Dissimilarity Index Values - Black / Non-Black 1970

Dissimilarity Index Values - Black / Non-Black 1990



Dissimilarity Index Values - Black / Non-Black 2000



Dissimilarity Index Values - Hispanic/ Non-Hispanic 1970

Dissimilarity Index Values - Hispanic/ Non-Hispanic 1990

Dissimilarity Index Values - Hispanic/ Non-Hispanic 2000