Measuring a Redistricting Plan's Deviation from Population Equality and Its Effect on Minorities: New Mexico's Experiment with a "Votes Cast" Formula

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INTRODUCTION

In early 1982, New Mexico redistricted its legislature using a "votes cast" formula to estimate precinct and legislative district population. The formula essentially assumed that the number of residents in a voting precinct was proportional to the number of voters in a previous election. A three-judge federal court later ruled, on "one person, one vote" grounds,[1] that New Mexico's use of the votes cast formula violated the fourteenth amendment's equal protection clause.[2] This Article uses New Mexico's votes cast formula to illustrate how statistics can assist lawyers in determining whether deviations from population equality, including "minor" deviations which might otherwise pass constitutional scrutiny, cause underrepresentation of racial or ethnic minorities.

Full and effective voting representation demands election districts which, at a minimum, comply with one person, one vote principles and treat racial minorities fairly. The fourteenth amendment requires compliance with equal population criteria and prohibits redistricting plans

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[1] Gray v. Sanders, 372 U.S. 368, 381 (1963) ("The conception of political equality from the Declaration of Independence to Lincoln's Gettysburg Address, to the Fifteenth, Seventeenth and Nineteenth Amendments can mean only one thing — one person, one vote.").

[2] Sanchez v. King, 550 F. Supp. 13 (D.N.M.), *aff'd mem.*, 103 S. Ct. 32 (1982).

which underrepresent minorities.[3] Whenever different size districts exist, even if the differences are not large enough to trigger one person, one vote concerns, the population deviation may adversely affect minority residents. Further, when redistricting plans rely on a base other than census population, systematic bias may be introduced. Plans which deviate from population equality, or are based on factors other than census population, are suspect and should be examined carefully to insure no underrepresentation of minorities.

In recent years, statistical evidence has played an increasingly important role in resolving claims of racial discrimination.[4] This Article describes some commonly accepted statistical methods which are available to measure minority underrepresentation. The analysis is offered as an aid to those responsible for developing constitutionally permissible redistricting plans as well as those interested in evaluating whether the plans pass constitutional scrutiny. The focus is on a statistical model consisting of quantitative data and empirical techniques. It supplements the traditional, anecdotal approach to burden of proof considerations. Statistical applications, such as those offered here, provide lawyers with powerful and persuasive tools to evaluate voting redistricting plans.

The analysis is presented in the context of New Mexico's use of votes cast in the 1980 election to fashion a 1982 legislative redistricting plan. There are two reasons why it is important to examine closely this and other similar redistricting plans. Recent case law, in an effort to address other legitimate redistricting considerations, such as the preservation of county boundaries, permits substantial deviation from population equality.[5] In addition, some courts and legislatures have found it appropriate to rely on nonpopulation considerations such as the number of eligible voters, registered voters, or, in the case of New Mexico, the actual number of votes cast.[6]

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[3] *See infra* notes 15-17 and accompanying text.

[4] *See, e.g.*, Sugrue & Fairley, *A Case of Unexamined Assumptions: The Use and Misuse of the Statistical Analysis of* Castaneda/Hazelwood *in Discrimination Litigation*, 24 B.C.L. REV. 925 (1983); *see also* D. BALDUS & J. COLE, STATISTICAL PROOF OF DISCRIMINATION (1980) (a general treatment of the use of statistics to prove racial discrimination).

[5] Brown v. Thomson, 103 S. Ct. 2690 (1983) (89% deviation from population equality permitted to preserve integrity of county boundaries).

[6] "Use of registered voter figures as an index for districting in lieu of population figures is constitutionally permissible." Bowden v. Stacy, 309 F. Supp. 510, 513 (S.D. Ala. 1970); *see* Simon v. Landry, 419 F.2d 1329 (5th Cir. 1969) (approving use of voting registration data to redistrict Lafayette, Louisiana's police jury); Martin v. Venables, 401 F. Supp. 611 (1975) (permitting use of registered voter data to redistrict Stratford, Connecticut's town council).

While underrepresentation of protected groups may occur in any voting plan, systematic underrepresentation is more likely in districting plans which rely on a base other than total population. Examples of nontotal population bases include voting age population, eligible voters, registered voters, and voting turnout or votes cast. Any such redistricting base is likely to introduce enough bias to call into question whether the plan results in a lack of equal access to the political process. Accordingly, a strong incentive exists for measuring racial or ethnic impact. By applying commonly accepted statistical techniques, it is possible to accurately measure a redistricting plan's deviation from total population. Once the population deviation is known, statistical methods make it possible to determine whether a significant association exists between the deviation and ethnicity and, if so, whether the plan tends to substantially underrepresent racial or ethnic minorities.

I. Scope of the Problem — Fourteenth Amendment Considerations

The fourteenth amendment requires states, when fashioning redistricting legislation, to construct single-member voting districts as near to "equal population as is practicable."[7] In assessing the validity of legislative redistricting plans "[t]he ultimate inquiry . . . is whether the legislature's plan 'may reasonably be said to advance [a] rational state policy' and, if so, 'whether the population disparities among the districts that have resulted from the pursuit of this plan exceed constitutional limits.' "[8] Under such a standard, courts often permit substantial deviation from precise population equality.[9] Prior to *Brown v. Thomson*,[10] it was widely assumed that redistricting plans with more than

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[7] Reynolds v. Sims, 377 U.S. 533, 577 (1964) (striking, for the first time, a legislative districting plan on ground it violated fourteenth amendment's equal protection clause); *see* Avery v. Midland County, 390 U.S. 474 (1968) (equal population principles apply to districted local governments). For a partial list of redistricting litigation in the Supreme Court, see National Conference of State Legislators, Reapportionment Law and Technology 47 Table 1 (1980) [hereafter Reapportionment Law and Technology].

[8] Brown v. Thomson, 103 S. Ct. 2690, 2696 (1983) (quoting Mahan v. Howell, 410 U.S. 315, 328 (1973)) (preservation of county boundaries justified 16% deviation from population equality).

[9] *Id.* at 2697; *see also* Reapportionment Law and Technology, *supra* note 7, at 48-49 Table 2A (chart providing case name, deviation, whether or not sustained, and justification for pre-1978 Supreme Court redistricting cases).

[10] 103 S. Ct. 2690 (1983).

sixteen percent overall deviation[11] "approach tolerable limits."[12] Notwithstanding legitimate nonpopulation considerations such as the preservation of county boundaries, such plans were viewed as unlikely to pass constitutional scrutiny.[13] In *Brown*, however, the Court upheld "a state legislative plan with an 89% maximum deviation from population equality."[14]

While a redistricting plan may contain some deviation from population equality, it may not discriminate against minority residents. Significantly, the Court in *Brown* made a point to note that "there is not the slightest sign of any group of people being discriminated against here."[15] Thus, *Brown* is consistent with the fundamental principle that all redistricting plans, even those with minor population deviations, must be "free from any taint of . . . discrimination"[16] and contain no "built in" bias favoring any particular group or interest.[17] In *Karcher*

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[11] Overall deviation is the largest district's deviation from ideal population plus the smallest district's deviation from ideal population, ignoring "+" or "-" signs. Ideal population is the total population of the jurisdiction divided by the number of districts. Overall deviation is often used synonymously with total or maximum deviation. For a definition of many statistical terms used in redistricting, see REAPPORTIONMENT LAW AND TECHNOLOGY, *supra* note 7, at 6-9.

[12] Mahan v. Howell, 410 U.S. 315, 329 (1973).

[13] *Id.* As a general rule, deviations of less than 10% create no prima facie equal protection violation. Connor v. Finch, 431 U.S. 407, 418 (1977) ("maximum [court ordered] population deviations of 16.5% in the [Mississippi] Senate districts and 19.3% in House districts can hardly be characterized as *de minimis*; they substantially exceed the 'under 10%' deviations the Court has previously considered to be of prima facie constitutional validity"); *see Brown*, 103 S. Ct. at 2696 ("A plan with larger disparities in population, however, creates a prima facie case of discrimination and therefore must be justified by the State."); White v. Regester, 412 U.S. 755, 764 (1973) (no prima facie violation of fourteenth amendment; total deviation 9.9%); Gaffney v. Cummings, 412 U.S. 735, 751 (1973) (minor deviations of 7.83% insufficient to make out prima facie violation of fourteenth amendment); Abate v. Mundt, 403 U.S. 182, 184-85, 187 (1971) (sustaining 11.9% deviation based on state efforts to reduce overlapping functions of political subdivisions and preventing duplication of services); Swann v. Adams, 385 U.S. 440, 444 (1967) (striking Florida plan with deviations of 26% and 34%).

[14] *Brown*, 103 S. Ct. at 2699 (O'Connor, J., concurring); *see also id.* at 2698 (majority opinion).

[15] *Id.* (quoting the district court, 536 F. Supp. 780, 788 (D. Wyo. 1982) (Doyle, J., specially concurring)).

[16] Roman v. Sincock, 377 U.S. 695, 710 (1964) (companion case to Reynolds v. Sims, 377 U.S. 533 (1964), striking Delaware's redistricting plan on fourteenth amendment grounds); *see Brown*, 103 S. Ct. at 2696; *see also* Chapman v. Meier, 420 U.S. 1, 19 n.13, 24 (1975) (striking, on fourteenth amendment grounds, court-ordered North Dakota redistricting plan with 23% deviation from population equality).

[17] *Brown*, 103 S. Ct. at 2696; Abate v. Mundt, 403 U.S. 182, 185-86 (1971). Courts

v. Daggett,[18] Justice Stevens explained:

> The "one person one vote" rule, like the Equal Protection Clause in which it is firmly grounded, provides protection against more than one form of discrimination. . . . [Although t]he primary consequence of the rule has been its protection of the individual voter [from plans with excessive and unjustifiable deviation], . . . it has also provided one mechanism for identifying and curtailing discrimination against cognizable groups of voters.[19]

Although most redistricting plans rely on census-based total population,[20] the Supreme Court sanctioned counting only state citizens in *WMCA, Inc. v. Lomenzo*.[21] In *Burns v. Richardson*,[22] the Court went on to note that the use of registered voters, or other nonpopulation bases, was proper "if it appears that the distribution of registered voters approximates [the] distribution of state citizens or another permissible population base."[23] A decision to redistrict on the basis of total population or, alternatively, on a nonpopulation base such as eligible, registered, or actual voters, is likely to have a profound effect on minority representation.[24] This is particularly evident in jurisdictions where mi-

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should give careful scrutiny "to the character as well as the degree of deviation from a strict population basis." Reynolds v. Sims, 377 U.S. 533, 581 (1964).

[18] 103 S. Ct. 2653 (1983) (New Jersey congressional redistricting case in which Court found that overall population deviation of 0.6984% violated article I, § 2 of Constitution).

[19] *Id.* at 2668 n.6 (Stevens, J., concurring). Other "mechanisms" may include the fifteenth amendment. *See, e.g.*, Gomillion v. Lightfoot, 364 U.S. 339 (1960) (striking Alabama's efforts to redraw Tuskegee's boundaries disenfranchising blacks but not whites); *see also* Voting Rights Act of 1965, Pub. L. No. 89-110, 79 Stat. 437 (codified as amended at 42 U.S.C. §§ 1973 to 1973dd-6 (1976 & West Supp. 1983)).

[20] *See, e.g., Karcher*, 103 S. Ct. at 2657 n.1; *see also* REAPPORTIONMENT LAW AND TECHNOLOGY, *supra* note 7, at 51 Table 3.

[21] 377 U.S. 633, 641, 653 (1964).

[22] 384 U.S. 73 (1966).

[23] *Id.* at 95. In addition to state citizens or total population, eligible voters or voting age population may also be a permissible population base. *See* Kirkpatrick v. Preisler, 394 U.S. 526, 534 (1969) ("Assuming without deciding that apportionment may be based on eligible voter population rather than total population . . . .").

[24] Sanchez v. King, 550 F. Supp 13 (D.N.M.) (use of voting data resulted in 94% deviation from total population), *aff'd mem.*, 103 S. Ct. 32 (1982). The proper population base ultimately depends upon the nature of the constitutional right which is protected. *Compare, e.g.*, Gaffney v. Cummings, 412 U.S. 735, 746 (1973) ("[I]f it is the weight of a person's vote that matters, total population . . . may not actually reflect that body of voters whose votes must be counted and weighed for the purposes of reapportionment, because 'census persons' are not voters.") *with* Kirkpatrick v. Preisler, 394 U.S. 526, 531 (1969) ("Equal representation for equal numbers of people is a principle designed to prevent debasement of voting power and diminution of access to elected

norities were historically denied access to the ballot.[25] A plan based on eligible voters, for example, is likely to appear fair when compared to voting age population. The same plan, however, may have a substantial adverse effect on minorities when compared to total population. One reason is that minorities often have a younger median age than the population as a whole and, accordingly, fewer of them are eligible to register and vote.[26] Even accounting for age, however, minorities still register and vote at a rate substantially lower than nonminorities.[27]

To determine how nonpopulation-based plans affect minorities, they should be compared to a plan based on total census population. The Supreme Court has repeatedly approved plans based on total census population.[28] It has never sanctioned, however, the use of eligible, registered, or actual voters as a permissible redistricting base. It is useful, therefore, to compare these bases, or any other nonpopulation base, with citizen or total population.[29] The purpose of the comparison is to

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representatives.") Plans which equalize the number of voters or potential voters but deviate from equal population appear vulnerable. Reynolds v. Sims, 377 U.S. 533, 565 (1964) ("[E]ach and every citizen has an inalienable right to full and effective participation in the political processes of his State's legislative bodies."); *see* Calderon v. City of Los Angeles, 4 Cal. 3d 251, 258-259, 481 P.2d 489, 493, 93 Cal. Rptr. 361, 365-66 (1971) ("Adherence to a population standard [in a voting redistricting case], rather than one based on registered voters, is more likely to guarantee that those who cannot vote or do not cast a ballot may still have some voice in government.").

[25] The Court in Burns v. Richardson, 384 U.S. 73, 92-93 (1965), warned that the use of registered voter data to redistrict could enable those in power "to perpetuate underrepresentation of groups constitutionally entitled to participate in the electoral process, or perpetuate a 'ghost of prior malapportionment.'" *Id.* (citing Buckley v. Hoff, 243 F. Supp. 873, 876 (D. Vt. 1965)). In Ely v. Klahr, 403 U.S. 108 (1971), Justice Douglas stated:

> If all segments of society were equally likely to register to vote, then the [registered voter] method of computing population would be unobjectionable. But all members of a community are not equally likely to register. . . . Not only are the poor, the blacks, the Chicanos, and the Indians less likely to register in the first place, they are also likely to have a higher rate of illiteracy among their members.

Id. at 118 (Douglas, J., concurring).

[26] In New Mexico, for example, 1980 census data reveals that about 36% of the minorities are under 18 years of age, while only about 27% of the whites fall in that group. *See* CENSUS OF POPULATION AND HOUSING, 1980: SUMMARY TAPE FILE 1A (New Mexico) [machine-readable data file]/*prepared by the* DATA USERS SERVICE DIVISION, BUREAU OF THE CENSUS — WASHINGTON: THE BUREAU Tables 7, 12, 13 (1981) [hereafter CENSUS SUMMARY TAPE].

[27] *See infra* Figure 2 and accompanying text.

[28] *See supra* note 20 and accompanying text.

[29] *Cf.* Travis v. King, 552 F. Supp. 554, 555-65 (D. Hawaii 1982) ("[T]here is some

determine how nonpopulation-based redistricting plans affect racial or ethnic minorities. The analysis which follows demonstrates that redistricting plans with bases other than total population are particularly likely to systematically underrepresent minorities.

II. New Mexico's Votes Cast Formula

In 1966, New Mexico was forced to design new legislative districts. Following the Supreme Court's decision in *Reynolds v. Sims*,[30] a three-judge federal court held that the state's districting plan violated the fourteenth amendment's equal population criteria.[31] Lack of readily available precinct population data, however, made the task of constructing new legislative districts difficult. The boundaries of voting precincts, the primary building blocks of larger legislative districts, differed substantially from the boundaries of units used by the Census Bureau to tabulate total population.[32] As a result, New Mexico chose to estimate the population of each voting precinct rather than to adopt census geography or ask the Census Bureau — at substantial cost — to retabulate the actual precinct populations. The formula used to estimate precinct populations, called the votes cast formula, was based on the number of votes cast in a precinct, the total county vote, and the total census population.

Expressed as an equation, the votes cast or estimated population formula can be written:[33]

$$\text{Estimated Precinct Population} = \text{Precinct Vote} * \frac{\text{County Census Population}}{\text{Total County Vote}}$$

The formula estimates precinct population by assuming that the ratio of population to voters in every precinct is the same as for the county as a whole. The ratio for the county is determined by dividing the county's population, readily available from the Census Bureau, by the total county vote. This ratio of total county population divided by total

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merit to the argument that the state at least show the impracticality of a district-by-district comparison [with a permissible population base] before being permitted to go forward with a registered voter based apportionment.").

[30] 337 U.S. 533 (1964).

[31] Beauchamp v. Campbell, No. 5778, slip op. (D.N.M. Mar. 31, 1966).

[32] R. Folmar, Legislative Apportionment in New Mexico 1844-1966, 58-59 (1966). Special tabulations were, however, available from the Census Bureau and others.

[33] *Id.* at 49.

county vote is then multiplied by the number of votes in a particular precinct to arrive at the precinct's estimated or votes cast population.[34] In this way, the votes cast formula distributes the county's total census population in each of its precincts in proportion to the voting turnout in the last general election.

The 1982 legislative redistricting plan, based on precinct populations estimated by the votes cast formula, was challenged as violating the fourteenth amendment's equal population criteria. In *Sanchez v. King*,[35] plaintiffs alleged that the formula resulted in legislative districts with impermissibly high deviations from total population. The deviations were said to violate one person, one vote standards and, in addition, to result in systematic underrepresentation of minorities.[36] The court ultimately found:

> The record demonstrates that the application of the formula for ascertaining precinct population . . . cause[d] substantial variations between the numbers thereby derived and United States Census figures. This comes about by reason of the inclusion of the *total vote* cast as an element of the formula. These variations are not constant throughout the counties, districts or precincts. . . . The disparities have such consequence that we conclude that the "votes cast formula". . . leads to a result which is constitutionally impermissible.[37]

III. The Effect of the Votes Cast Formula on Deviations from Census Population

The first step in determining whether the votes cast formula adversely affects minorities is to gather the available quantitative data. To fully evaluate the formula, it is necessary to know for a number of legislative districts the following figures:[38] the formula's estimated pop-

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[34] The votes cast formula works as follows: In a county with a census population of 100,000 and 40,000 votes in the last election, county census population (100,000) is divided by the total votes (40,000). The result is a ratio of county population divided by county votes or, in the example, 2.5. If 600 individuals voted in a particular precinct, the votes cast formula estimates precinct population by multiplying the number of precinct voters (600) by the ratio of county population divided by county vote (2.5). The result is a votes cast estimated population of 1500 persons.

[35] 550 F. Supp. 13 (D.N.M.), *aff'd mem.* 103 S. Ct. 32 (1982).

[36] Because it found the 94% deviation from total population impermissibly high, the *Sanchez* court did not reach the racial issue. Had the deviation been less than 94%, had New Mexico's justification been more substantial, or had the court relied on a population base other than total population, it might have chosen to decide the case on the alternative racial claim.

[37] *Sanchez*, 550 F. Supp. at 14 (emphasis in original).

[38] This Article evaluates the 22 legislative districts in Bernalillo County, New Mex-

ulation,[39] the total census population,[40] the number of racial or ethnic minorities,[41] the number of registered voters,[42] and the number of votes cast.[43]

In order for the votes cast formula to accurately predict district population, the proportion of the population who voted must be the same in every legislative district. The data indicates, however, that this is not the case in New Mexico. In fact, in Bernalillo County, which is analyzed because of its large size and complete racial data, the ratio of the votes cast estimated population (EP) to the census population (CP) (denoted as EP/CP) ranges from 0.64 to 1.44.[44] The first of these numbers represents district 13, for which the estimated population of 19,270 is 36% smaller than its census population of 29,912.[45] The second number represents district 30, for which the estimated population of 18,954

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ico (Albuquerque).

[39] NEW MEXICO LEGISLATIVE COUNCIL SERVICE, ESTIMATED PRECINCT POPULATIONS (1980).

[40] This data is not normally available by precinct in New Mexico. If it were available, the argument for using the votes cast formula would be undermined. By going back to the maps and raw data, the Census Bureau can make special tabulations of population and housing counts, but this is costly and time consuming. Demographers outside the Census Bureau can perform similiar analyses, but since they lack access to the detailed raw census data, assumptions must be made. The resulting estimates are less precise than census tabulations but probably not biased: errors are likely to be random and off-setting rather than systematic. The census population and race data relied on in *Sanchez* and reflected in this Article were estimated by the Middle Rio Grande Council of Governments. Sometime after the population estimates were performed, the Census Bureau was asked to tabulate the actual precinct populations. A comparison of the actual population figures prepared by the Census Bureau with the precinct population estimates prepared by the Council of Governments shows a remarkably similiar result for most of Bernalillo County's over 300 voting precincts.

[41] Demographers are able to approximate the racial composition of a precinct by prorating the number of minorities according to the estimated population totals. Here, such data was prepared by the Middle Rio Grande Council of Governments.

[42] NEW MEXICO SECRETARY OF STATE, STATE OF NEW MEXICO OFFICIAL RETURNS 1980 GENERAL AND PRIMARY RETURNS (1980).

[43] *Id.* Depending on the amount of data and other factors, it may be helpful to collect the quantitative information in a computer data base. The information here — the formula's estimated population, census total population estimates, racial estimates, numbers of registered voters and numbers of votes cast, together with certain identifying characteristics — was assembled in a data base using DIGITAL PDP 11.70 minicomputer equipment.

[44] For each legislative district, the ratio is the estimated population (from the votes cast formula) divided by the census population. A ratio greater than 1.0 indicates that the estimated population exceeds the census population, and vice versa.

[45] Note that the ratio minus 1.00 equals the percent deviation. For example: 0.64 - 1.00 = -0.36, or -36%.

is 44% larger than its census population of 13,140.[46] The range of the deviation from census population for legislative districts in Bernalillo County is -36% to +44%, for a total or overall deviation of 80%.[47]

The mean relative deviation[48] is a good overall summary of the district by district deviations in a state or county. Comparing the estimated district populations to the ideal district population,[49] which in New Mexico is 18,613, the mean relative deviation is only 2.6% in Bernalillo County. On the other hand, when comparing the actual census-based district populations to the ideal district, the mean relative deviation is 20.3%. Thus while the deviations in Bernalillo County seem small when measured by the votes cast estimated population, they are substantial when measured by the census population.

IV. The Effect of the Votes Cast Formula on Racial and Ethnic Minorities

Not only were there significant differences between the votes cast formula's estimates and the census-based population figures, the errors tended to correlate with the ethnic composition of legislative districts.[50] The analysis showed that predominantly minority legislative districts almost always had a higher census population figure than attributed to them under the votes cast formula.[51] Conversely, largely white districts almost always had less actual census population than that estimated by the votes cast formula.[52] The result was a systematic underrepresentation of predominantly minority districts and a corresponding overrepresentation of those districts which were mostly white.

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[46] 1.44 - 1.00 = 0.44, or 44%.

[47] The range is the difference between the largest ratio (1.44) and the smallest (0.64). Thus the range is 1.44 - 0.64 = 0.80, or 80%.

[48] The mean relative deviation is the sum of the relative absolute deviations (expressed as a percentage of the ideal district, *see supra* note 11, and ignoring sign) divided by the number of districts.

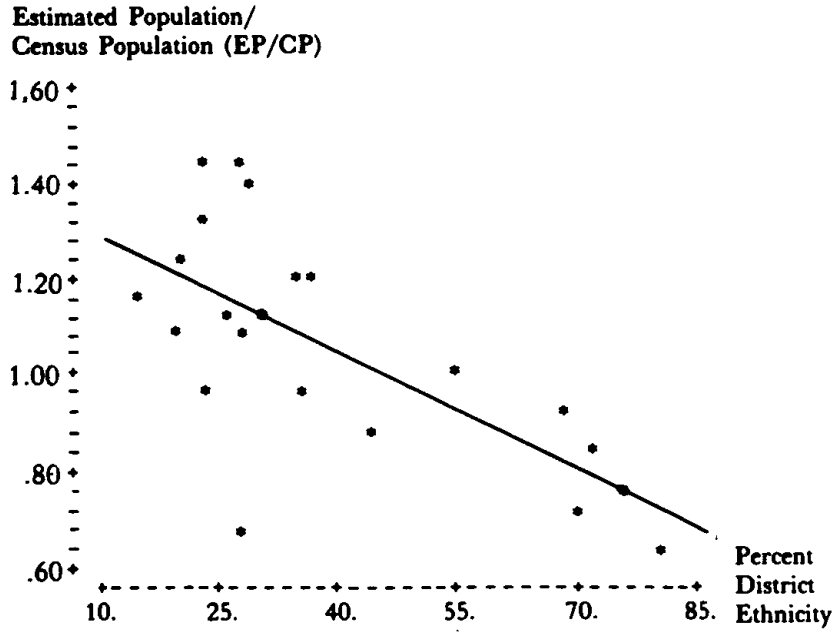
[49] *See supra* note 11.

[50] Correlation is a "measure of the mutual relationship between two variables." G. Snedecor & W. Cochran, Statistical Methods 172 (6th ed. 1967).

[51] *See infra* Figure 1. The horizontal axis of Figure 1, percent districts ethnicity, demonstrates that in every instance but one, predominantly minority districts (districts to the right of 55 on the horizontal axis) have a larger actual census population than votes cast estimated population.

[52] *See infra* Figure 1. The opposite is also true. Predominantly nonminority districts (districts to the left of 55 on the horizontal axis in Figure 1) tend to have a smaller actual population than votes cast estimated population.

FIGURE 1[53]
House Districts in Bernalillo County



Correlation of EP/CP and Ethnicity = −0.688

Figure 1 is a comparison of the ratio of estimated votes cast formula population to census population (EP/CP) with ethnicity. Ethnicity is defined as the proportion of the population who are black, Indian, or Asian, plus the proportion who are hispanic.[54] Each dot in the scattergram corresponds to one legislative district in Bernalillo County. The vertical axis represents the ratio of estimated votes cast population to census population.[55] Higher values indicate overestimates; any district above 1.0 has a higher estimated votes cast population than census population.[56] Conversely, any district below 1.0 has a lower estimated votes

[53] Figures 1-3 *infra* reflect data on 22 New Mexico House of Representatives districts in Bernalillo County, including the city of Albuquerque. The scattergrams, correlation coefficients, and least squares regression lines have been prepared using the data base described *supra* note 43 and a MINITAB statistical software program. *See* T. RYAN, B. JOINER & B. RYAN, MINITAB STUDENT HANDBOOK (1976).

[54] While this definition results in black hispanics being counted twice, there are few black hispanics in New Mexico. *See* CENSUS SUMMARY TAPE, *supra* note 26, at Table 9.

[55] *See supra* note 44.

[56] In other words, the votes cast formula estimates more residents in a particular district than are enumerated by the Census Bureau. Since total census population is the

cast population than census population. Districts with population values above 1.0 are overrepresented compared to census population and districts with population values below 1.0 are underrepresented compared to census population. The horizontal axis represents the proportion of the population who are black, Indian, Asian and hispanic. Higher values indicate more ethnic districts. The population of any district to the right of 55 in Figure 1, for example, is more than 55% ethnic.

District 13, noted earlier with an EP/CP ratio of .64, is located at the lower right of the Figure 1 scattergram and has an 80% ethnic population. District 30, which has an EP/CP ratio of 1.44, is located at the upper left of the scattergram and has a 22% ethnic population. The message is that the more ethnic districts tend to have lower values of EP/CP.[57] The votes cast formula underestimates the population of legislative districts with larger proportions of minorities and therefore gives them less representation in the legislature. Similarly, the formula overestimates the population of legislative districts with few minorities, overrepresenting their smaller numbers.

The analysis can be extended to reflect the degree to which the votes cast formula underrepresents minorities. As we noted previously, a correlation coefficient is a measure of the degree of association between two variables.[58] The coefficient takes on a value between 1.0 and -1.0. A value of 1.0 indicates perfect positive correlation: the points fall exactly on a line that slopes up from left to right.[59] A value of -1.0 also indicates perfect correlation, but on a line sloping downward from left

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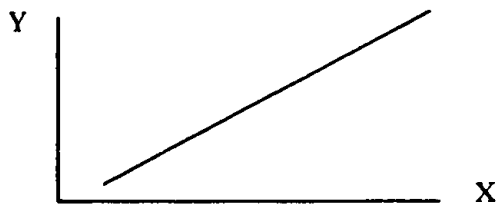
touchstone, the population of such a district is overestimated.

[57] In other words, districts with high minority concentrations tend to have actual census populations larger than the population estimate based on the votes cast formula. In fact, every district with a minority concentration of more than 70% has a larger actual than estimated population. *See supra* Figure 1 and notes 44, 51.

[58] *See supra* text accompanying note 50; *see also* D. FREEDMAN, R. PISANI & R. PURVES, STATISTICS 109-25 (1978) [hereafter FREEDMAN].

[59] Expressed graphically, a perfect positive correlation of 1.0 would appear as follows:



correlation (r) = 1.0

to right.[60] A value of zero indicates absolutely no relationship between the variables.[61] For the Bernalillo County legislative district data, the correlation coefficient was -.688, which indicates a substantial degree of association between the votes cast formula's deviation from total population and the ethnicity of legislative districts.

Even if there is no real association between the two variables, the correlation coefficient in any particular set of data is never exactly zero; random fluctuations in the data make it larger or smaller. For a set of 22 data points, if there is no real association, statistical theory says that the probability of obtaining a correlation of -.688 or less by chance alone is less than one in a thousand.[62] This means that the results are statistically significant; we can be reasonably sure that the observed association between ethnicity and the amount of population deviation in legislative districts is not due to chance.[63]

A further statistical tool, linear regression analysis, is available to summarize the amount of error in the votes cast formula for typical high and low ethnicity districts.[64] The line drawn through the data in Figure 1 is a "least squares regression line." This means that it is the

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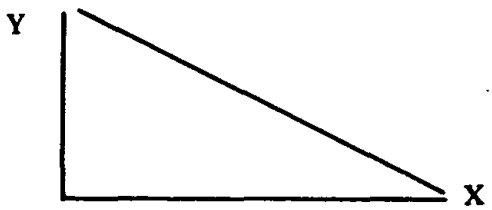
[60] Expressed graphically, a perfect negative correlation of -1.0 would appear as follows:



correlation (r) = −1.0

[61] A correlation of absolutely zero could either mean that the points fall exactly on a perfectly horizontal line, or more likely, show absolutely no tendency toward linearity.

[62] G. SNEDECOR & W. COCHRAN, *supra* note 50, at 172-98.

[63] *Id.* An association between two variables does not necessarily mean that one causes the other. Normally, to prove causality, social scientists require two or three sorts of ideas in addition to association: (1) consistency — when other things are equal, the relationship betwen two variables is consistent across populations; (2) responsiveness — if we intervene and change one variable the other will respond accordingly; and (3) a mechanism — that there is an understandable step-by-step mechanism that relates cause and effect. Only the first of these three ideas can be confirmed by observation alone. *See* F. MOSTELLER & J. TUKEY, DATA ANALYSIS AND REGRESSION 260-61 (1977).

[64] Regression analysis is often used to describe the relationship between two variables, and in particular, to summarize the amount of change in one variable (the dependent variable) associated with a certain change in the other variable. For a full discussion, see FREEDMAN, *supra* note 58, at 146-85.

line that best fits the data in that the sum of the squares of the vertical deviations of the points from the line is minimum. It can be interpreted as an average EP/CP corresponding to specific values of ethnicity. For example, a district with a 75% ethnic population would have, on the average, a ratio of estimated votes cast population to census population (EP/CP) of 77% — a 23% undercount or underrepresentation.[65] On the other hand, a district with a 25% minority population would have, on the average, a 17% overcount or overrepresentation.[66] Thus, a 50% point (75% minus 25%) difference in ethnicity on the horizontal axis corresponds to a 40% point (23% plus 17%) difference in EP/CP on the vertical axis. Such a difference is persuasive evidence that the error introduced by the formula is not only statistically significant but also quite severe.

V. Contribution of Registration and Turnout to Population Deviation

To explain why the estimated population or votes cast formula underrepresents minorities, it is helpful to perform analyses similar to that just discussed on the formula's component elements. The two components of voting are the proportion of the population which is registered and, of those registered, the proportion which actually votes. By expanding the equation, it is possible to view the two components of voting independently and measure the error in each. The estimated population or votes cast formula says that:

$$\text{Population(EP)} = \text{Precinct Vote(V)} * \frac{\text{County Census Population (CCP)}}{\text{County Vote (CV)}}$$

or symbolically:

$$EP = V * \frac{CCP}{CV}$$

The vote in each precinct is the product of three factors: the precinct

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[65] The regression line can be calculated by most standard statistical computer programs, and even by many pocket calculators. In this case, if Y represents the vertical axis or EP/CP and X represents the horizontal axis or percent ethnicity, the equation of the regression line is $Y = 137 - 0.8X$. Thus when $X = 75$, $Y = 77$. Graphically, if a line were drawn vertically at a point on the horizontal axis corresponding to a 75% ethnic district, it would intersect the least squares line at 77%, indicating a 23% underestimate.

[66] Following the notation set out *supra* note 65, when $X = 25$, $Y = 117$. A vertical line through the point on the horizontal axis corresponding to a 25% ethnic district would intersect the least squares line at 117%, indicating a 17% overestimate.

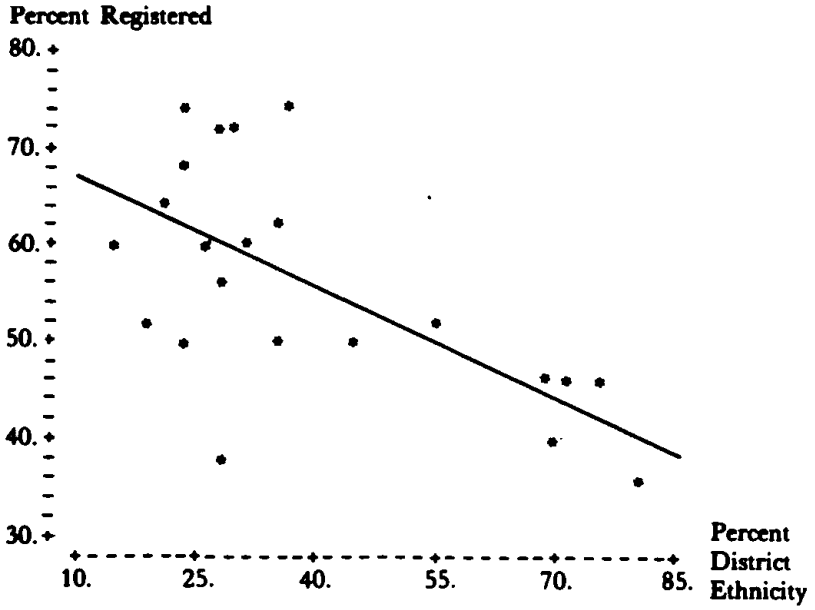
population, times the proportion of the population who are registered to vote, times the proportion of those who actually turnout to vote. This means that we can write the votes cast formula as:

$$EP = CP * \frac{R}{P} * \frac{V}{R} * \frac{CCP}{CV}$$

In words, the votes cast estimated population (EP) for a particular precinct is the census population (CP), times the proportion of the population that is registered to vote (R/CP), times the proportion of the registered voters who actually turn out to vote (V/R), times a factor which is the same for each precinct in the county (CCP/CV).

If the proportion who register and proportion who vote are the same in every district, the estimated population or votes cast formula would be a good measure of the census population. To determine whether this is the case, however, we must first compare the proportion of the population who are registered to the proportion of the population who are minorities.

FIGURE 2
House Districts in Bernalillo County[67]



Correlation of Percent Registered and Ethnicity = −0.631

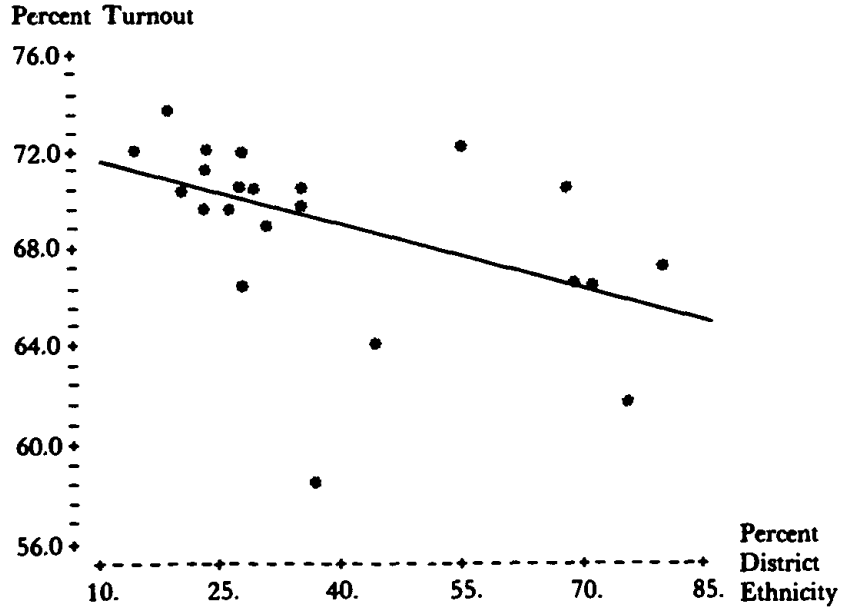
[67] For an explanation of how the information was generated, see *supra* text accompanying notes 43, 56.

Figure 2 compares the proportion registered to the proportion ethnic. The correlation coefficient of these two variables is -.631, indicating a substantial, statistically significant, association.[68] Furthermore, comparing a district with a 75% ethnic population and a district with a 25% ethnic population, we would expect to find an 18% lower proportion of registered voters in the minority district.[69]

Figure 3 summarizes the same sort of analysis for the proportion of registered voters who turned out to vote and ethnicity. The correlation coefficient is -.456, which is significant. There is only a 4% difference in turnout, however, between a 75% ethnic and a 25% ethnic district.[70]

FIGURE 3

House Districts in Bernalillo County[71]



Correlation of Turnout and Ethnicity = −0.456

The above analysis demonstrates that racial and ethnic differences in registration and voting were reasons why both the estimated population

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[68] *See supra* note 50 and accompanying text.

[69] This is an average figure, the result of a simple regression analysis comparing the proportion registered to the proportion ethnic. *See supra* notes 64-66 and accompanying text.

[70] This is an average figure, the result of a simple regression analysis comparing the proportion voting to the proportion ethnic. *See supra* notes 64-66 and accompanying text.

[71] *See supra* notes 64-66 and accompanying text.

or votes cast formula gave biased population estimates. Of the two components, however, differences in the rate of minority registration, much more than turnout, contributed to the formula's error and resulting deviation from population equality.[72] Table 1 illustrates these statistical findings by comparing two actual legislative districts. The two are typical in that their graph points fall near the regression line in Figure 1.

TABLE 1

A Comparison of Bernalillo County House Legislative Districts 19 and 12

	District 19	*District 12*
Percent Ethnicity[73]	32%	70%
Total Population[74]	16,498	24,725
Percent Registered[75]	60%	40%
Number Registered[76]	9,957	9,858
Percent Voted[77]	69%	67%
Number Voted[78]	6,833	6,565
Votes Cast Formula Estimated Population[79]	18,765	18,028
Deviation From Total Population[80]	+14%	−27%

In two legislative districts with a difference of ethnicity of 38%, the formula overestimates by 14% the population of largely white district 19 and underestimates by 27% the population of largely minority dis-

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[72] *See, e.g.*, Table 1, *infra* text accompanying notes 73-80. Largely minority district 12 has 20% less registered voters than largely white district 19, but only 2% less voter turnout.

[73] *See supra* note 41 and accompanying text.

[74] *See supra* note 40 and accompanying text.

[75] *See supra* note 42 and accompanying text (expressed as a percentage of total population).

[76] *See supra* note 42 and accompanying text. Data is from the 1980 general election.

[77] *See supra* note 42 and accompanying text (expressed as a percentage of registered population).

[78] *See supra* note 42 and accompanying text. Data is from the 1980 general election.

[79] *See supra* note 39 and accompanying text.

[80] The deviations are expressed as a percent of total population. If the deviations were expressed as a percent of ideal population the total deviation would be slightly higher.

trict 12. The net result is the relative overrepresentation of district 19, in which only sixteen thousand people share one representative, and the relative underrepresentation of district 12, in which twenty-four thousand people also share one representative. When we compare the number of registered voters[81] with each district's census population, we find that 60% of largely white district 19 is registered while only 40% of largely minority district 12 is registered. In the same two districts, 69% of district 19's registered voters turned out at the polls while 67% of district 12's registered population actually voted — a difference, however, of only 2%.

Had data on voting age population[82] or eligible voting population[83] been readily available by precinct or legislative district,[84] the analysis could have been expanded to the three principal factors affecting the accuracy of the formula: the proportion of the population that is eligible to vote, the proportion of the eligible population that is actually registered, and the proportion of the registered population that actually turns out to vote. An informal analysis along these lines, using county rather than district data, suggests that ethnic differences in the second factor — registration of the eligible population — were largely responsible for the error observed in the votes cast formula.[85] Such an observation, while necessarily limited because it is based in part on county and not on legislative district data, is nonetheless consistent with a number of cases.[86]

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[81] More precisely, this is a combination of the eligibility and registration component of voting.

[82] Voting age population is the proportion of the population 18 years of age or older.

[83] Eligible voting population is the voting age population minus those precluded from voting by state law, e.g., individuals convicted of a felony.

[84] One reason why voting age population was not readily available below the county level was the Census Bureau's "suppression" of age data. Under certain circumstances, to ensure confidentiality, age and other data (but not population or race data) are unavailable. *See* CENSUS OF POPULATION AND HOUSING, 1980: SUMMARY TAPE FILE 1 TECHNICAL DOCUMENTATION/*prepared by the* DATA USER SERVICES DIVISION, BUREAU OF THE CENSUS — WASHINGTON: THE BUREAU 19-29 (1981).

[85] Using the identical methodology employed throughout this Article, but with county rather than legislative district data, we find a correlation between the proportion of the county population that is of voting age and county level ethnicity of -0.548. While statistically significant, such a correlation coefficient would result in a relatively minor difference in voting age populations among New Mexico's counties. For example, the proportion of the population 18 years or older in a county with a minority population of 75% would be, on the average, about 5% points lower than in a county with a 25% minority population.

[86] *See, e.g.*, Ely v. Klahr, 403 U.S. 108, 118 (1971) (Douglas, J., concurring); *see also* Ellis v. Mayor of Baltimore, 352 F.2d 123, 129-30 (4th Cir. 1965) ("[T]he danger

CONCLUSION

Total population or the number of state citizens remains the only population base sanctioned by the Supreme Court.[87] Reliance on voting age population, voting registration date, or voter turnout when fashioning redistricting legislation is likely to result in substantial deviations from population equality and to have a decidedly adverse impact on minorities.[88] As we have seen, any New Mexico plan based on eligibility, registration, or votes cast will undercount districts with a large minority population and provide relatively less representation to its inhabitants than they deserve.[89] The opposite, of course, also is true. Any New Mexico plan based on eligibility, registration, or votes cast will overcount districts with large white populations and provide more representation than they deserve.

Whether redistricting plans with deviations correlating with race violate the fourteenth amendment may depend on more than adverse racial impact alone.[90] The Supreme Court noted, in *Washington v.*

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inherent in the validation of a voter registration base [for redistricting purposes] is that it is readily susceptible of abuse, and if abuses should arise the burden of proving them would be difficult to sustain."); Yelverton v. Driggers, 370 F. Supp. 612, 615 (M.D. Ala. 1974) ("[T]he use of registered voter statistics [rather than population] as a base for [redistricting] would result in a pattern wildly disproportionate to the population. Plaintiffs point out . . . that only 43% of Dothan's age-eligible blacks are registered voters, as compared with 72% of the age-eligible whites in Dothan."); Calderon v. City of Los Angeles, 4 Cal. 3d 251, 481 P.2d 489, 93 Cal. Rptr. 361 (1971).

[87] *See supra* note 23 and accompanying text.

[88] We have only shown this to be true in New Mexico, but it probably is true elsewhere as well.

[89] *Cf.* Burns v. Richardson, 384 U.S. 73, 93 (1966) ("Such effects must be particularly a matter of concern where . . . figures derived from a single election are made controlling for as long as 10 years."). Here, as we have seen, minorities are a proportionately larger share of those under 18 and, accordingly, a proportionately larger share of those who will become eligible to vote by turning 18 during the multi-year life of the plan. For a recent discussion of registered voters or voting age population as a population base, see Travis v. King, 552 F. Supp. 554, 565-69 (D. Hawaii 1982) ("We note, however, that since *Reynolds* courts at all levels have held that use of voter blind populations, either total or state citizen populations, adequately serves the requirement of 'one person, one vote.' "). *Id.* at 565 n.25.

[90] Washington v. Davis, 426 U.S. 229, 242 (1976) (purpose and not merely effect necessary to prove fourteenth amendment violation); *cf.* Wright v. Rockefeller, 376 U.S. 52, 55 (1964) (when issue not variation in size of districts but segregative effect of congressional redistricting plan, Court accepted "the findings of the majority of the District Court that appellants failed to prove that the New York Legislature was either motivated by racial considerations or in fact drew the districts on racial lines"). The Court went on to require a showing that the redistricting legislation "was the product

Davis,[91] "Disproportionate impact is not irrelevant, but it is not the sole touchstone of an invidious racial discrimination forbidden by the Constitution."[92] Even so, evidence of minority underrepresentation or adverse impact remains "an important starting point"[93] which should be examined carefully when districts deviate from census population equality and geographically concentrate racial or ethnic minorities.

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of a state contrivance to segregate on the basis of race or place of origin." *Id.* at 58. *But see* Voting Rights Act of 1965, Pub. L. No. 89-110, 79 Stat. 437 (codified as amended at 42 U.S.C. §§ 1971, 1973 to 1973dd-6 (1976 & West Supp. 1983)). A redistricting plan may violate amended § 2 if it is applied "in a manner which *results* in a denial or abridgement of the right of any citizen of the United States to vote on account of race or color" (emphasis added). This is the so-called amended § 2 "results" test.

[91] 426 U.S. 229 (1976).

[92] *Id.* at 242.

[93] Village of Arlington Heights v. Metropolitan Hous. Dev. Corp., 429 U.S. 252, 266 (1977).