The Identification and Evaluation of Racial Gerrymandering

John O'Loughlin

Annals of the Association of American Geographers is currently published by Association of American Geographers.

Articles

The Identification and Evaluation of Racial Gerrymandering

John O'Loughlin

Department of Geography, University of Illinois at Urbana-Champaign, Urbana, IL 61801

Abstract. Despite the elimination of differences in the population sizes of election districts, gerrymandering of district boundaries remains an obstacle to full equality for all social and political groups. Legal challenges to district lines on grounds of racial-vote dilution frequently fail because plaintiffs cannot show evidence of discriminatory intent on the part of the redistricting authorities and because no accepted measure of gerrymandering has been developed. A disputed redistricting may be one of hundreds of feasible, constitutional ways to redraw district lines. Charges of racial bias were evaluated using a statistical framework. Congressional districts in Manhattan were favorable to blacks, whereas districts in New Orleans and Mississippi were unfairly drawn to dilute black voting power. Courts, academics, and legal experts can use this evaluation method to determine the fairness of a proposed reapportionment or to judge a plan's equity for social or political interest groups.

Key Words: racial gerrymandering, discriminating intent, feasible districtings, modal and tail solutions.

THE decennial political struggle over legislative reapportionment is currently under way in the American states. Changes in district lines are accompanied by claims of threatened incumbents, of minorities seeking representation in proportion to their numbers, of reform groups urging nonpolitical computer redistricting, and of editorial writers condemning the unseemly partisan spectacles. National population trends have resulted in the shifting of seventeen congressional seats from the Northeast and Midwest to the South and West, with New York losing five seats and Florida gaining four. Intrastate population changes generally favor Republican strongholds in suburban and exurban areas, but Democrats hope to use their control of two-thirds of state legislatures to reduce the worst effects of redistricting on their representation. Both parties have spent millions of dollars to hire lawyers and computer experts and to purchase computer redistricting packages. Many reapportionment plans will face legal challenges on grounds of minority-vote dilution through discriminatory boundary delimitation; some plans may be challenged on partisan grounds. Redistricting plans are now designed to meet the "one-man, one-vote" (equal population) requirement. Gerrymandering, defined as biased district lines designed to help a group and hurt its opponents, inevitably will be the grounds of most legal challenges. Despite a common belief that gerrymanders are easy to identify, the history of gerrymandering cases in the courts shows the opposite. The lack of a legal and technical standard against which a challenged map can be compared has doomed most allegations of gerrymandering. The purpose of this paper is to propose a method that can be used by the courts and other participants in reapportionment to evaluate allegations of vote dilution through gerrymandering.

A combination of census undercounts and discriminatory cartography has led minorities

to feel that they are denied proportional representation by deliberate means (Bailey 1980). Mayor Richard Hatcher of Gary wrote that "the importance of black participation in politics becomes academic if black hopes are cut off at the political pass by tactical devices" (Hatcher 1969, p. 306). As the "tactical devices" have become more sophisticated, reliance on simple cartographic methods is not enough to show discrimination. The sophistication of vote-dilution techniques must be matched by equally sophisticated evaluation methods if allegations of discrimination are to be upheld in court.

The fear of a nonpolitical plan imposed by a court or a special commission is sufficient to spur most legislatures to reach bipartisan agreement. Choice of technical procedures is overshadowed by the choice of political and equity criteria to be implemented in a redistricting plan. Location-allocation algorithms are available for redistricting tasks, and techniques for evaluation of the outcomes are well known to social scientists (Craig 1973; Wollock 1980). However, a complete procedure for the design and evaluation of election districts remains elusive. Recent work by British geographers has pointed to a profitable route of redistricting implementation and evaluation (Gudgin and Taylor 1979; Johnston 1979). Before these methods can be applied in the American context, the constitutional bases of redistricting must be reviewed and special attention given to the standards of proof in a gerrymander case. Only by placing the proposed redistricting system in a legal context can its importance be understood and its choice be justified.

The Legal Framework

Legal resolution of the issues raised by the division of states and cities into legislative districts has been clouded by related considerations. These include an ideological shift on the U.S. Supreme Court, the demand for proportional representation by minorities, the attempts by politicians to save their seats, a sharp clash between proponents of affirmative action and advocates of neutral nondiscriminatory methods of allocation, confusion about the technical elements of redistricting, and, most importantly, an unresolved conflict as to whether redistricting is essentially a po-

litical matter or one better removed from self-interested politicians. Review of court opinions and law review articles on redistricting revealed shifting and contradictory beliefs, noncompliance by lower courts with Supreme Court guidelines, appeals for Supreme Court clarification of a legal standard in gerrymandering cases, and a lack of understanding by many lawyers and judges of the deeper ramifications of reapportionment plans. The adoption of the gerrymandering evaluation procedure proposed in this article is predicated on a legal base: a review of important legal issues is necessary to indicate the standards to be met in successful litigation.

To challenge a redistricting plan, evidence must be gathered to show that the constitutional provisions for district delimitation were violated. Using the Fourteenth and the Fifteenth Amendments, the Supreme Court has maintained that the population sizes of election districts at all levels of government should be approximately equal. Beyond equal population, other criteria do not appear consistently. A review of state constitutions by Adams showed that 49 states have written reapportionment criteria into their state constitutions, with all states requiring districts to be equal in population. Twenty-two states require their districts to be compact, and 29 states require contiguity in districts. Additionally, a few states require the map maker to respect political boundaries (Adams 1977). A recent review of criteria for "fair and effective representation" listed 16 possibilities, many of which conflict with each other (Lijphart 1981). The impetus for many of these criteria comes from the belief that representatives should be responsive to their constituents and that proportional representation for minorities should be protected (Niemi and Deegan 1978).

The vast majority of Supreme Court decisions on redistricting have concerned the issue of equality in population size between the electoral districts of states and cities. Accepting the principle that legislative redistricting was a constitutional issue in 1962 (*Baker v. Carr* 1962), the Supreme Court ordered numerous states to reapportion seats to match geographic shifts in population (*Reynolds v. Sims* 1964). In writing the Court's opinion, Chief Justice Warren wrote that "fair and effective representation is concededly the basic aim of legislative apportionment"

(*Reynolds v. Sims* 1964, at 565–66). The right to vote is a "fundamental right" (*Harper v. Virginia Board of Elections* 1966). Consequently, the Warren Supreme Court continued to place strict limits on the maximum population-percentage deviation from the largest to the smallest district. By 1969, the Court declared New York and Missouri Congressional district plans unconstitutional because they allowed largest-smallest deviations of 11.1 and 7.0 percent, respectively (*Wells v. Rockefeller* 1969; *Kirkpatrick v. Preisler* 1969). By the 1972 term, the reconstituted Burger Supreme Court began to move away from this strict standard for state legislative districts. In a Virginia case, the Court allowed a maximum largest-smallest deviation of 16 percent (*Mahan v. Howell* 1973).

In its malapportionment decisions, the Supreme Court has been helped by accepted measures of equal population. Population-percentage deviations beyond a certain percentage constitute a *prima facie* case of discrimination against the residents of the larger districts. (*Prima facie* evidence is sufficient to raise a presumption of fact or establish the fact in question unless rebutted.) The burden then shifts to the state to justify its plan on the basis of other considerations, such as the preservation of municipal and county boundaries (*Mahan v. Howell* 1973). The Supreme Court has ruled that limitations which place a "real and appreciable burden" on the right to vote are subject to "strict scrutiny" by the courts (*Bullock v. Carter* 1972).

The Supreme Court rulings on malapportionment stand in sharp contrast to its rulings on gerrymandering in two respects. First, the Court has accepted statistics as evidence of vote dilution through malapportionment by relying on population deviation figures to gauge the merit of plaintiffs' claims. In gerrymandering cases, the use of statistical evidence has been hindered severely by confusion among judges and lawyers over the choice of appropriate measures. Second, it is critical to note that the Supreme Court has consistently accepted the notion that evidence of discriminatory impact is sufficient to win a malapportionment case. Statistical evidence in the form of deviation measures is enough to sustain a plaintiff's claim, in the absence of a state rationale for sizeable population deviations. In gerrymandering and multimember-district cases, the Court's

majority requires evidence of purposeful intent to discriminate. The reason for this perplexing dual standard presumably lies in the absence of an accepted gerrymandering statistic, given the complex nature of vote dilution through gerrymandering. By comparison, malapportionment is simple.

The Supreme Court's rulings on malapportionment impinge on the gerrymandering issue in a number of unobtrusive ways. By allowing population deviations up to 10 percent, the Court has prevented backdoor challenges to gerrymandered districts. Plaintiffs, wishing to challenge a gerrymander but knowing the Court's double standard, have frequently based their claims on population-deviation statistics. On the other hand, the Burger Supreme Court has made gerrymandering more difficult by observance of political boundaries as the building blocks of legislative districts. It is clear that the courts are willing to rule on obvious vote dilution, as in malapportionment, but are not willing to rule on less egregious forms of vote dilution through multimember districts and gerrymandering. This discrepancy has resulted in a situation where states carry the burden of proof of justifying population variations in malapportionment cases but plaintiffs carry the burden of proof in gerrymandering cases.

Most court decisions on gerrymandering have involved allegations of vote dilution through multimember districts. The court has ruled that multimember districts are not per se unconstitutional but multimember districts could violate the equal protection clause of the Fourteenth Amendment. A plaintiff must prove that the disputed plan "was conceived and operated as a purposeful device to further racial discrimination" (*Whitcomb v. Chavis* 1971, at 149). It is clear that the evidence of uneven impact as *prima facie* proof of vote dilution is no longer sufficient. The recent Burger Court rulings on racial discrimination in multimember district and ad hoc gerrymandering cases are related to the standards enunciated in *Washington v. Davis* (1976) (a police hiring case) and in *Arlington Heights v. Metropolitan Housing Corporation* (1977) (a zoning case). Because of difficulty of showing intent, it is no wonder that the liberal members of the Supreme Court wished to abide by an earlier standard of vote dilution, which declared unconstitutional electoral arrangements that were "designed to or would

operate to minimize or cancel out the voting strength of racial or political groups" (*Fortson v. Dorsey* 1965).

The Supreme Court has ruled on only half a dozen claims of ad hoc gerrymandering, that is, vote dilution through discriminatory boundary delimitation. Commentators have argued that the court should complete the "equal representation" process by preventing the continuing abuse of gerrymandering (Baker 1971; Edwards 1971). The Court has been hindered severely in its quest for a gerrymandering standard by lack of agreement on what constitutes "fair and effective representation." Can racial minorities be represented adequately only by legislators of the same race? Is it better to control one district with a majority of the vote or have a strong voice in two or more districts with a large minority of the vote? Most minority strategists would choose the "bird-in-hand" option. Is anything less than proportional representation evidence of racial discrimination in district delineation? The Court has consistently said no, but some commentators wish to redress the gap with "affirmative action" gerrymandering (Derfner 1981; for an alternative view, see Wells 1981). Does the trend toward bipartisan agreement on redistricting inevitably hurt future minority electoral prospects? Is gerrymandering on racial grounds unconstitutional but gerrymandering on partisan grounds acceptable as part of the normal political process? Given that the Court has refused to invalidate any alleged partisan gerrymander but has declared a plan unconstitutional as a racial gerrymander, this belief has merit (*Gaffney v. Cummings* 1973; *Gomilion v. Lightfoot* 1960). These questions plague research and legal theory and place the Supreme Court in the position of navigator in an unchartered legal and technical ocean.

The Supreme Court has established the principle that the state's power to draw political boundaries is limited. A city boundary reorganization in Tuskegee, Alabama, that placed all but three or four of 400 black residents outside the city limits and thus disenfranchised them in city elections was unconstitutional. The Tuskegee gerrymander had three characteristics: "(1) the 28-sided configuration was 'uncouth,' that is to say, it was manifestly not the product of a routine or traditional political decision; (2) it had a signifi-

cant adverse impact on a minority group; and (3) it was unsupported by any neutral justification and thus was either totally irrational or entirely motivated by a desire to curtail the political strength of the minority" (*City of Mobile v. Bolden* 1980, J. Stevens concurring at 4445). It was not until 1964 that an allegation of ad hoc racial gerrymandering of electoral districts reached the Supreme Court. Manhattan's four congressional districts, with black population percentages of 86.3, 28.5, 27.5, and 5.1, were allegedly a "stacked" (excess vote) gerrymander (Figure 1a). The Court's majority ruled that "the plaintiffs failed to prove that the New York Legislature was motivated by racial considerations or in fact drew the districts on racial lines" and that the plaintiffs "had not shown that the challenged part of the New York Act was the product of a state contrivance to segregate on the basis of race or place of origin" (*Wright v. Rockefeller* 1964, at 56, 58). The majority stated further that the geographic concentration of blacks in Harlem "made it difficult, even assuming it to be permissible, to fix districts to have anything like an equal division of these votes among the districts" (*Wright v. Rockefeller* 1964, at 47). In this case, evidence of "discriminatory intent" was specifically required by the court. Justice Goldberg said that "to require a showing of racial motivation in the Legislature would place an impossible burden on complainants" (*Wright v. Rockefeller* 1964, J. Goldberg dissenting at 73). Subsequent events have shown him to be correct.

For the Southern states and scattered counties in five other states covered by the 1965 Voting Rights Act, it is possible to shift the burden of proof in voting dilution cases to the districting authority. Section 5 of the Act requires localities to submit electoral changes for preclearance to the United States Attorney General or to the federal district court in the District of Columbia. Numerous plans have been invalidated since 1965 as retrogressive. The Supreme Court, when upholding the constitutionality of Section 5, also affirmed Congress's right to place the burden of proof on the authorities (*South Carolina v. Katzenbach* 1966). A review of cases emanating from the preclearance requirement showed that "those who reside in states affected by the 1965 Voting Rights Act have neither this burden (of proof) nor the burden

of initiating litigation to combat districting changes which have a potentially discriminating effect" (Halpin and Engstrom 1973, p. 46). They concluded that the Attorney General has been much less restrained in invalidating ad hoc gerrymanders while demonstrating a cautious sensitivity to multimember districting.

Two ad hoc gerrymandering cases that originated in areas covered by the Voting Rights Act have reached the Supreme Court. The Court ruled 7-1 that it was permissible for the New York legislature to delineate state legislative districts for Brooklyn to correct for past invidious discrimination. The tightly knit Hasidic Jewish community of Williamsburgh claimed that they were the victims of this "affirmative action" gerrymander because their community was divided among majority-black districts. Chief Justice Burger, the lone dissenter, complained that the decision "suggests to the voter that only a candidate of the same race, religion or ethnic origins can properly represent that voter's interest, and that such candidate can only be elected from a district with a sufficient minority concentration" (United Jewish Organizations of Williamsburgh v. Carey 1977, J. Burger dissenting at 186).

The other racial gerrymandering case debated in the Supreme Court involved claims of "cracked" or wasted-vote gerrymandering. After the 1970 census, the New Orleans City Council redrew its five districts to create one black-voting-majority district (the city population was 45 percent black). The Attorney General disapproved the plan under Section 5 of the Voting Rights Act. This was his second disapproval; the City Council had complied with his first disapproval. The City Council appealed to the Supreme Court to overturn the Attorney General's disallowance and to allow the second (Moreau) plan to be used. The court ruled 6-2 that the Moreau plan did not remotely approach a constitutional violation. The court clearly stated the "nonretrogression" principle, which will not allow a diminution of black voting strength through districting. The Moreau plan was accepted because two black population-majority districts, including one black-voting-majority district, were created. The reasoning of the court's majority can be criticized on the grounds that they were concerned with relative change when only absolute change matters.

Justices Brennan and Marshall supported absolute change to measure "amelioration" and, as Justice Marshall pointed out, if the pre-apportionment districts had been left in situ, one black-voting-majority district would result (Beer v. United States 1976).

The Supreme Court denied a hearing to an appeal from a Mississippi congressional districting case decided in the lower courts. The Mississippi congressional district reapportionment was part of a long and complicated vote-dilution case. A three-judge federal court upheld the change in congressional districts, even though the 17 majority-black counties were subdivided into three new districts (Figure 5a). The lower court dismissed any intensive examination of the change when it held that "one factor, and only one, may be taken into account in apportioning and establishing congressional districts among the people of a state and that factor is population" (Connor v. Johnson 1966, at 619).

This review of legal decisions has made two points clear. First, the burden of proof in gerrymandering cases lies with the plaintiffs and has proven to be an "impossible burden." When the burden of proof was shifted to states by the Attorney General, under the Voting Rights Act, most could not show "intent not to gerrymander" and found themselves in a position similar to plaintiffs alleging "intent to gerrymander." Second, understanding of the biases inherent in the single-member system is still in infancy. It is expected that sophisticated statistical methods will be suggested to the courts for use in gerrymandering cases.

Disproportionate Impact and Gerrymandering

Many commentators have taken the position that uneven impact should constitute prima facie evidence of discrimination. They argue that, having demonstrated proof of uneven impact in race discrimination cases, the plaintiffs have shifted the burden of proof to the state, which must then show "compelling state interest" in upholding the plan. The rarity with which the state can show this compelling interest means that, for most situations, shifting the burden of proof is tantamount to victory (Eisenberg 1977; Weiner 1977). Uneven impact can be demonstrated.

After filtering the negative impact accruing to black representation from low turnout and demographic composition, uneven impact could be shown if the group's voting strength was diluted beyond that expected from their residential distribution. The plaintiffs' argument can be strengthened by evidence of a history of race discrimination. It is easier to find evidence of race discrimination for Southern states as the comparative results of two multimember district cases show (*White v. Regester* 1973 [Texas case]; *Whitcomb v. Chavis* 1971 [Indiana case]).

Race discrimination can be challenged on three grounds. The law may be facially discriminatory such as any legal classification that discriminates against a disadvantaged racial group, in the absence of a compelling state interest. The courts also recognize uneven impact but often require evidence of purposeful discrimination. Finally, "the law in a few instances may have an egregious impact on a racial minority [so] that intent may be inferred or irrelevant" (Berry and Dye 1979, p. 101). The egregious-impact standard has been accepted by the Burger Court, after they stated that uneven impact alone was insufficient to win a race discrimination case. "Sometimes a clear pattern, unexplainable on grounds other than race, emerges from the effect of the state action even when the governing legislation appears neutral on its face" (*Arlington Heights v. Metropolitan Housing Corporation* 1977, at 266). At what point does uneven impact become egregious impact in a redistricting case? The Court has not given a clear indication of its feelings on this distinction.

In a long article on the constitutional bases of uneven impact, Eisenberg developed the "causation principle," which will be used as the basis of the gerrymandering evaluation scheme proposed in this paper. Courts can find equal-protection violations when uneven impact is accompanied by factors more susceptible to proof than intentional discrimination. "Uneven impact should invite strict scrutiny if there is sufficient causal connection between the official classification and the uneven impact" (Eisenberg 1977, p. 57). Eisenberg argued that a suspect classification should arise when unintentional disproportionate impact is reasonably attributable to race, a result of a causal connection between alleged suspect characteristic and un-

even impact. His argument is based on the law of torts. "Applied to equal protection cases, the causation principle instructs a court to subject official actions to heightened scrutiny whenever the plaintiff can show that race was both a cause in fact and a proximate cause of disproportionate impact on minorities" (Eisenberg 1977, p. 58).

The difficulty of implementation of the causation principle in gerrymandering cases can be seen from Ely's analysis of impact standards in constitutional law. He stated that it is impossible for a court to conclude that a minority was harmed in a constitutionally cognizable sense unless the court has a standard of political representation to compare to challenged plans (Ely 1970). Justification of alternative boundaries is difficult in ad hoc gerrymandering cases. The best method to approach the causation principle lies in a comprehensive framework, so that a challenged reapportionment plan can be viewed with respect to all constitutionally feasible redistricting options.

The Identification of Gerrymanders

To most citizens, gerrymandering is equated with districts of strange shapes that wander across the political landscape to search for supporters or to lump opponents into packed districts. Obviously, residential concentration of party and racial groups determines some excess majorities. An even greater vote excess can be manufactured by deliberately biased cartography. Because this cartography often results in districts that are elongated, distended, or unshapely, gerrymandering has unfortunately become equated only with noncompact districts in the popular press and in legal publications.

Compactness measures and shape indices have been advocated to measure gerrymandering (Taylor 1973; Edwards 1971). The assumption that noncompact districts and districts with strange shapes (multisided with numerous indentations and extensions) constitute evidence of gerrymandering is probably accurate. Compactness scores have been used to measure gerrymandering, as in the comparison of compactness scores before and after the reapportionment revolution of the mid-1960s. Scores for black, white, and racially mixed districts in eight large Ameri-

can cities showed slightly greater compactness after reapportionment in all three types of districts (O'Loughlin 1976). Increasing compactness scores may not mean decreased gerrymandering. A shift from wasted to excess-vote gerrymandering may produce this phenomenon. Even though the shape measures are quite different, the end product remains the dilution of the vote of a particular group.

Other gerrymandering identification methods are confined to party voting on a national scale. Analysis of victory margins has been suggested as a method of determining deliberate gerrymandering. If the party responsible for the plan wins a significant number of narrow victories while the opposing party loses many sets narrowly and wins most of its seats overwhelmingly, suspicion arises that these results were manufactured through clever superimposition of district lines on the political mosaic (Prescott 1972; Tufte 1973). It is possible to compute the components of electoral bias, which is the difference between proportions of party seats and party votes. Electoral bias contributed by deliberate gerrymandering of districts can be measured (Gudgin and Taylor 1979, pp. 86−91; Johnston 1979, pp. 63−71). The components approach to gerrymander identification cannot be used in racial gerrymandering because black candidates usually emerge only from black areas.

On the assumption that the Supreme Court is reluctant to enter the "political thicket" of gerrymandering because of the absence of standards, two groups of political scientists hope to indicate the relative fairness of a challenged plan. The method of Backstrom et al. can be used only for partisan gerrymandering and is of no use in racial gerrymandering cases (Backstrom, Robbins, and Eller 1978). On the other hand, the Engstrom and Wildgen method was developed for a racial gerrymandering case in New Orleans. Because evaluation of vote dilution must be made with respect to residential distribution, proof of gerrymandering requires a demonstration that voting strength has been diluted egregiously beyond that which could be expected to result from residential patterns. Their evaluation scheme requires the generation of a large number of alternative plans, using only contiguity and equal population. Then, based on polarization scores for each

districting (these scores measure the concentration or separation of the black population in the districts), the probability that each districting arrangement occurs by chance is calculated. For the *Beer v. United States* (1976) racial gerrymandering case in New Orleans discussed above, Engstrom and Wildgen generated 165 alternative feasible districtings. They concluded that "the probability of a plan less desirable to blacks (than the challenged Moreau plan) occurring through impartial districting procedures is therefore .7642, a figure that certainly does not support a presumption of gerrymandering" (Engstrom and Wildgen 1977, p. 473). The first plan rejected by the Attorney General had an associated probability of .1251, and the authors conclude that this is sufficient to establish the presumption of gerrymandering. An NAACP plan had a probability of .8340 whereas a Republican plan had a probability of .9999, both constituting "benign" gerrymanders.

The Engstrom and Wildgen procedure has many advantages for the evaluation of racial gerrymandering. The method's particular strength lies in its statistical framework. By computing a polarization score for the group suspected of suffering vote dilution, for each feasible alternative, scores can be compared for alternatives and odds calculated for each districting. This proposed system builds upon existing practice, in which courts are often faced with a number of redistricting alternatives. The court reviews each plan and selects the one that provides the closest fit to accepted redistricting criteria. This approach is similar to that of Gudgin and Taylor (1979), whose work derives from the Jenkins-Shepherd reorganization of Detroit's school districts and parallels Pulsipher's theoretical scheme (Jenkins and Shepherd 1972; Pulsipher 1973). Gudgin and Taylor generate all possible feasible solutions to a districting problem (6 districts for 99 counties in Iowa, for example) and arrange the resulting polarization scores for the target group on a histogram. They discuss tail and modal choices and show that solutions with low polarization scores (they use F-ratios and between-variance) are more common for political parties in British cities. The form of the histogram will be a function of the underlying political mosaic, in turn a function of the spatial distribution of social classes. Gudgin and Taylor

suggest that modal choices are selected by cartographers from majority parties, nonpartisan agencies, and court masters, whereas tail solutions are likely to be selected by minority parties, bipartisan (gerrymandering) commissions, and boundary commissions trying to generate proportional representation (Gudgin and Taylor 1979, pp. 146–61).

The Gudgin and Taylor system is potentially superior to the Engstrom-Wildgen system in a number of respects. First, the statistical framework is formally derived and supported. Second, the choice of districting algorithm is superior because all feasible solutions are generated. (Engstrom and Wildgen do not identify their algorithm, but it is possible that even their large sample (n = 165) is biased, especially as they did not consider the compactness criterion.) Third, the use of between-variance or the F-ratio as the polarization score is superior to the subjective Engstrom-Wildgen score. By using a score based on the relative splitting/concentration of a group among districts, we can see the costs and benefits to its representation. A combination of the Engstrom-Wildgen and Gudgin-Taylor approaches provided the technical methods and evaluation procedures for this present study.

A Method of Evaluating Alleged Gerrymanders

It appears that the Supreme Court will continue to place the burden of proof in gerrymandering cases on plaintiffs. The system proposed in this article would allow a court to shift the burden of proof to districting authorities if certain conditions are met, namely, that the odds are low that a challenged plan was derived by chance. Plaintiffs claiming vote dilution on grounds of race are more likely to achieve success than those claiming partisan discrimination. A potentially useful feature of the proposed scheme is identification of pre- and post-redistricting impacts on the target group. The extent to which a plan meets the principle of nonretrogression can then be measured.

Examination of the residential distribution of the target group is critical both for the construction of a successful gerrymander and for the assessment of vote-dilution claims. Although many researchers have stressed the importance of the concentration of votes, few studies have examined the topic. Gudgin and Taylor (1974) concluded that vote concentration is essential for minority party success in a single-member system. Using a simulation of 50 elections, Wildgen and Engstrom showed that, after the removal of the effect of party strength on the number of seats obtained, more than half of the remaining variance was explained by geographical distribution of party votes. They concluded that the spatial distribution of partisan or group support should be taken into account in any measure of gerrymandering (Wildgen and Engstrom 1980). Special consideration was given to determination of the electoral mosaic in this present study. Measures of voter concentration were computed (Moran's I spatial autocorrelation statistic and segregation scores), turnout by the target group was estimated and, because this study examines allegations of racial gerrymandering, the extent of racial bloc voting was determined. Bloc voting remains strong in elections with candidates of different races (O'Loughlin 1980).

To place a challenged plan in context, a family of feasible solutions is needed. Feasible in this instance means constitutional, incorporating the usual requirements of equal population, compactness, and contiguity. The choice of districting algorithm is based on a number of factors. Most important is the scale of the problem, determined by the number of observations to be aggregated. Taylor (1974), in his review of districting algorithms, shows the low limits of most algorithms, and Morrill (1981) provides an extended discussion of the techniques of electoral districting. Given the size of the problems under review here, all feasible solutions using a program such as GROUP (Rossiter and Johnston 1981) could not be derived. A review of alternatives led to the choice of the Weaver-Hess algorithm as the best available. The algorithm has been used widely in districting research and application. The version chosen (LAP) is described by Goodchild (1973), although this program probably elevates the compactness criterion to a higher position than considered necessary by the courts.

The criteria set for the production of feasible solutions were strict. Districts had to be contiguous; the population had to lie within 3 percent of the average for congressional districts and 5 percent for state legislative and

city council districts; no more than 5 percent of the subunits could be split into different districts; and a minimum compactness score was defined as one-quarter for the ratio of the minimum-to-maximum diameter of the district. Other specific variables included unit distances and random starting points for each iteration. Each solution could be included only once and no barriers were specified. Numerous iterations were required to generate a large sample of constitutional solutions; the ratio of total solutions to constitutional solutions was nearly 3:1. For each city or state, an optimal redistricting solution was computed using the criteria defined above and numerous random starting points. The enormous computer costs for these large redistricting problems preclude the generation of more than 100 feasible solutions, particularly because the point of diminishing returns from further generations using random starting points is reached after 40 to 50 solutions. The sample for each is assumed to be representative of the family of feasible solutions.

After each feasible solution had been generated, the percentage black in each district was computed. The district black population was used to determine the number of black-majority districts. A black-majority district will not necessarily elect a black because black turnout is often lower than white turnout, the proportion of the population under 18 is greater for blacks than for whites, and fewer blacks are registered to vote. A polarization score, measuring the spread of the target group (blacks) across constituencies, was then computed for each feasible solution. Nine different polarization scores were tested for consistency, using the Mississippi 1960 data. They were the F-ratio, between-district variance, relative entropy, Herfindahl Index, Gini Coefficient, Segregation Index, and Wilks Lambda, Box's M, and percentage correctly classified from discriminant analysis (Gaile 1977). As the results were highly inter-correlated, it was decided to use the F-ratio in the absence of a stronger candidate. Because this index is the ratio of between- to within-variance for the group across districts, it provides a useful measure of district racial concentration (large F-ratio) and racial heterogeneity (low F-ratio).

The F-ratios were arranged in histograms, and the number of black-majority districts for each solution was identified (Figures 2, 4, 6). Modal and tail solutions are clearly identifiable. Because the F-ratios constitute raw scores, they were converted into standard normal deviates (Z-scores) so that the probability of picking any particular districting arrangement could be determined. As voting is a fundamental right, we can define a more "liberal" position for statistical significance than is normal in social science research. We define tail solutions as the 0 to .10 and .91 to 1.0 ranges. If a challenged plan falls in these ranges, we follow the Engstrom-Wildgen argument that the odds are low that this districting arrangement could have occurred by chance; consequently, the burden of justification should be shifted to the districting authority.

The sample of alleged gerrymanders to be examined was chosen on the bases of scale and significance. The 1964 Manhattan (*Wright v. Rockefeller*) case was the first case of alleged vote dilution through ad hoc gerrymandering considered by the Supreme Court. The 1976 New Orleans case (*Beer v. United States*) was important as a test case for the Burger Court and because the plaintiffs introduced the notion of absolute versus relative gain through reapportionment. Both of these gerrymanders involved urban areas. It was decided to add an alleged statewide racial gerrymander. Given the topic, the choice had to be a Southern state. Mississippi was chosen because of its long history of race discrimination, its leading position among Southern states in the number of gerrymandering cases, and because its mid-1960s reapportionment has been viewed as a blatant attempt to stymie black electoral success. The lengthy Mississippi congressional district case (*Connor v. Johnson* 1966) was selected for analysis.

The Evaluation of Racial Gerrymanders

Before we consider gerrymander allegations, a demographic and electoral profile of each situation must be provided and special attention given to the residential concentration of the black population. It is common procedure in gerrymandering cases for plaintiffs and defendants to gather social science data to buttress their arguments. The popula-

tion size and spatial segregation of the minority determine cartographic strategy in benign, neutral, or discriminatory manners.

Congressional Districts in Manhattan (Wright v. Rockefeller 1964)

The black plaintiffs in New York challenged that part of the overall state plan that concerned the four districts of Manhattan. The districts were drawn on the basis of the 1960 census population figures, which showed Manhattan's total population at 1,698,281, with a black percentage of 23.4. The congressional districts did not deviate more than 15 percent above or below the state average, a rarity in pre-1964 reapportionments. The Republicans controlled both houses of the legislature and the governorship and had carefully redrawn the Manhattan districts to retain a GOP majority in the 17th district in the high-income areas on the east side of the island (Baker 1971) (Figure 1a).

The black registration and turnout rates in Manhattan were low. New York City elections have not been characterized by racial bloc voting. The "Manhattan Coalition" of minorities and liberal whites was able to elect John Lindsay to the mayoralty in 1969 and 1973 and to remain as the dominant electoral bloc in the city during the 1960s. In 1966, for example, Percy Sutton, a black, was elected Borough President of Manhattan with 66 percent of the vote over two white opponents.

The black population of Manhattan was concentrated in Harlem. The 1960 segregation index for the island, based on census tract data, was 70.6, compared to an index of 75.2 for the whole city (Van Valey, Clark, and Wilcox 1977). An index of spatial autocorrelation, Moran's I, measures the contiguity of tracts with similar black percentages. In 1960, this index was .402; based on a null hypothesis of randomization, the index was extremely significant when converted into a standard normal deviate ($Z = 85.79$; $\alpha = .0001$). Of the three situations under review in this paper, blacks in Manhattan were most segregated. The easiest way to gerrymander a concentrated minority is through wasted-vote districts. However, if the minority is large enough to dominate more than one district, the optimal gerrymander strategy is to create an excess vote district at the core of the minority

area and split the rest among majority-dominated districts. The black plaintiffs in *Wright v. Rockefeller* (1964) alleged an excess vote gerrymander in the 18th District (Figure 1a).

Fifty-nine alternative redistrictings were generated in this study for the 270 census tracts of Manhattan using LAP, the location-allocation procedure outlined above. (More than 160 plans were generated, but only 59 met the minimum threshold on the population and geographic criteria for inclusion as constitutional alternatives.) Fifteen sets of districts produced one black-majority district; 44 plans had no black-majority district (Figure 2). For each plan, the F-ratio measuring the relative splitting or concentration of black voters among districts was computed. The F-ratio ranged from 8.33 to 94.96. In general, redistrictings that produced elongated districts running north-south gave low F-ratios, and east-west solutions were more compact, giving medium-to-high F-ratios. The optimal redistricting had an F-ratio close to the center of the distribution and produced compact districts running east-west. However, the optimal plan had no black-majority district because district lines neatly bisected the black population concentration (Figure 1b). When the black community was divided three ways, the F-ratio was even lower (Figure 1c).

The leptokurtic form of the histogram of F-ratios reflects the geographic delineation of the island and the concentration of the black population at the northern end (Figure 2). Most feasible solutions adopted an east-west orientation, giving medium F-ratios. Solutions with high F-ratios, concentrating the black population into one district and producing a large between- to within-variance ratio, are most advantageous for the black community. The F-ratios were converted into standard normal deviates so that the probability associated with each alternative could be obtained. The Z-score associated with the actual plan was 2.78, which places the plan at the 99.46 percentile (Figure 1a). The odds that this plan would occur by chance are less than 1 in 100, and the plan certainly is a right-tail solution. According to the legal argument advanced earlier, this Congressional districting plan should have been subjected to strict scrutiny and the burden of justification shifted to the districting agency, in this case, the Republican-dominated legislature.
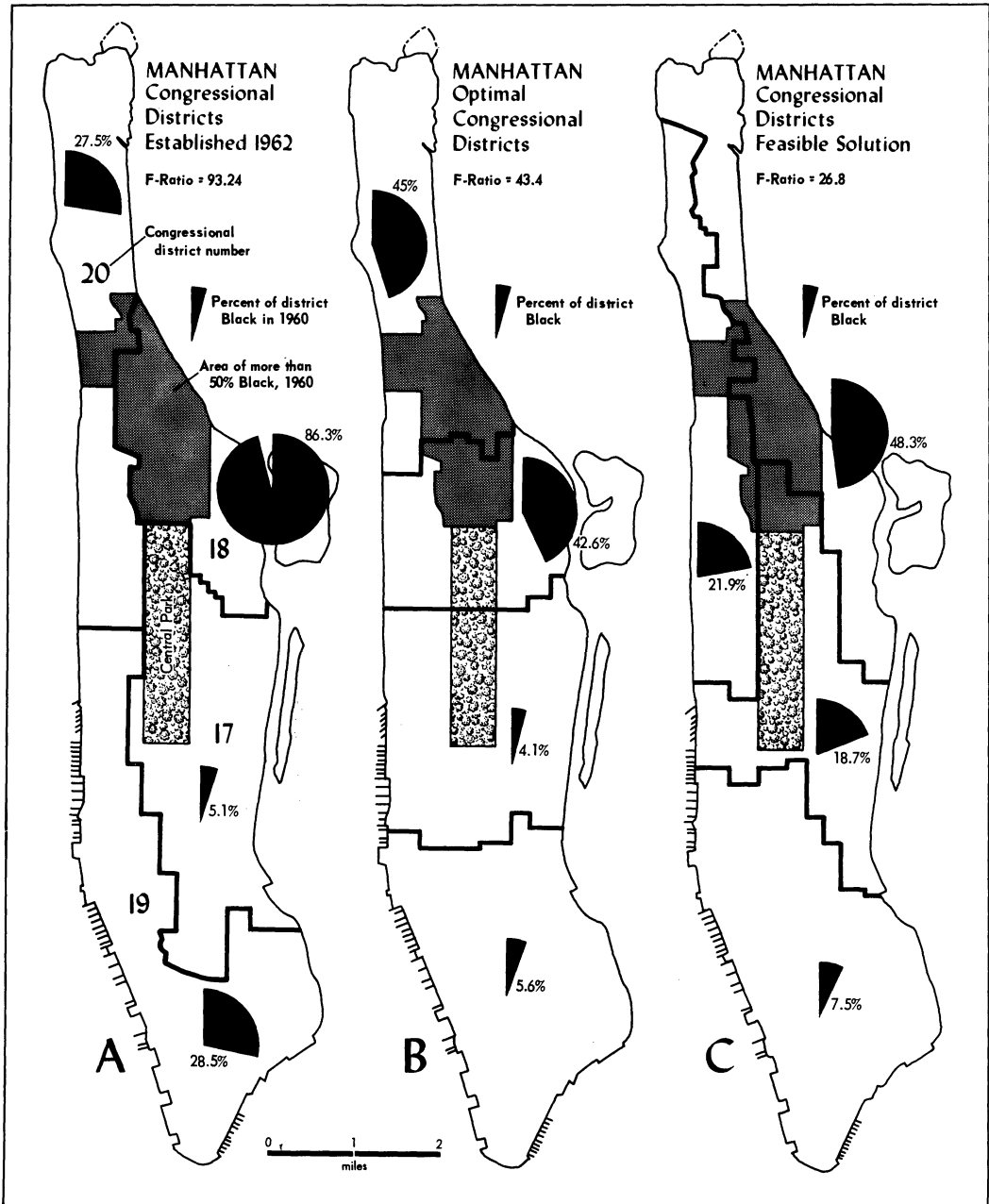
Figure 1. Actual and feasible congressional districts, Manhattan, 1964.

Does the above evidence constitute proof of gerrymandering? We can argue for both sides. There is little doubt that the Republicans wished to safeguard their seat on Manhattan's East side. To accomplish this, they had to exclude as many Democratic voters as possible. Given that blacks are overwhelmingly Democratic, the pro-Republican gerry-mander meant that the district line had to follow the racial line, and the arrangement constituted a pro-black gerrymander. Adam Clayton Powell, the sitting Congressman from the 18th District, argued for the status quo against his own constituents. The evidence presented here shows him to be correct in his assessment. Relatively few ways existed to
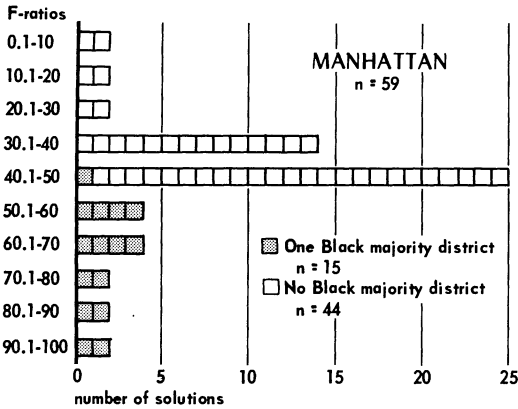
Figure 2. Distribution of F-ratios for Manhattan's feasible solutions.

create a safe black-majority district in Manhattan; the challenged plan was one of those few alternatives. It was an arrangement that benefited two sets of interests, blacks and Republicans. Intentionally or not, the plan created one safe seat for blacks when the modal districting choice for Manhattan would be no black district. Justice Douglas found *prima facie* evidence of segregated districts, stating that "racial boroughs are . . . at war with democratic standards," and he advocated nonpolitical, nonreligious, and nonracial reapportionment (*Wright v. Rockefeller* 1964, J. Douglas dissenting at 62). The evidence presented here also supports Justice Douglas; the argument then devolves to the nature of representation and the principle of colorblind equality. In 1964, the black population of Harlem was divided over what constituted "fair and effective" representation. In 1981, many blacks would argue for any arrangement that maximized their political strength, regardless of its segregated nature. A pro-black gerrymander is seen by them as superior to a nonpolitical and nonracial alternative that may dilute the black vote.

City Council Districts in New Orleans (Beer v. United States 1976)

The black population of New Orleans constituted 45 percent of the total population in 1970 but only 34.5 percent of the total registered voters. Black voters in New Orleans have a record of high turnout, particularly in

racially divided elections. Bloc voting is characteristic of New Orleans elections. The 1977 mayoral runoff showed clearly the racial nature of New Orleans elections, with Ernest Morial, the black victor, adding 19 percent of the white vote to almost unanimous black support to win the election (Rosenzweig and Wildgen 1978). Unlike that of Manhattan, the black population of New Orleans is found in all parts of the city but is primarily concentrated in an east-west crescent-shaped belt (Figure 3). Lewis (1976) has shown that residential segregation in New Orleans is not as pronounced as in other American cities. Numerous blocks and census tracts contain sizeable portions of both races. Based on census tracts, the residential segregation index in 1970 was 67.7, down from 70.9 in 1960 (Van Valey, Clark, and Wilcox 1977). Moran's I statistic of spatial autocorrelation was .0690 ($Z = 12.12$; $\alpha = .0001$) indicating contiguity of similar black population percentages, but the statistic was significantly lower than was the case for Manhattan.

Wards in New Orleans follow the street pattern from river to lake; election districts based on the 15 wards also assume an elongated north-south shape. They therefore cut across the grain of the black population concentration, as in the case of the challenged redistricting (Figure 3a). The Supreme Court ruled that, because the district plus at-large electoral arrangement predated the 1965 Voting Rights Act, it was not unconstitutional; the issue then became solely one of ad hoc gerrymandering. Black plaintiffs argued that the division of the black-registered voting population into districts of 52.6, 43.2, 36.8, 23.3, and 22.6 percent constituted vote dilution (Figure 3a). The corresponding black population percentages were 58.8, 50.6, 43.5, 41.4, and 31.4. Though the plan under scrutiny (Moreau plan) was an improvement over the first City Council effort turned down by the Attorney General (the first plan contained no district with a black voter majority), blacks and the Attorney General argued that two black-registered-majority districts were needed to produce proportional representation. Engstrom and Wildgen, in their review of the case, concluded that "a plan that provides a black registration majority in one of five districts does not egregiously dilute the black voting strength" (Engstrom and Wildgen 1977, p. 473). They based this conclusion on
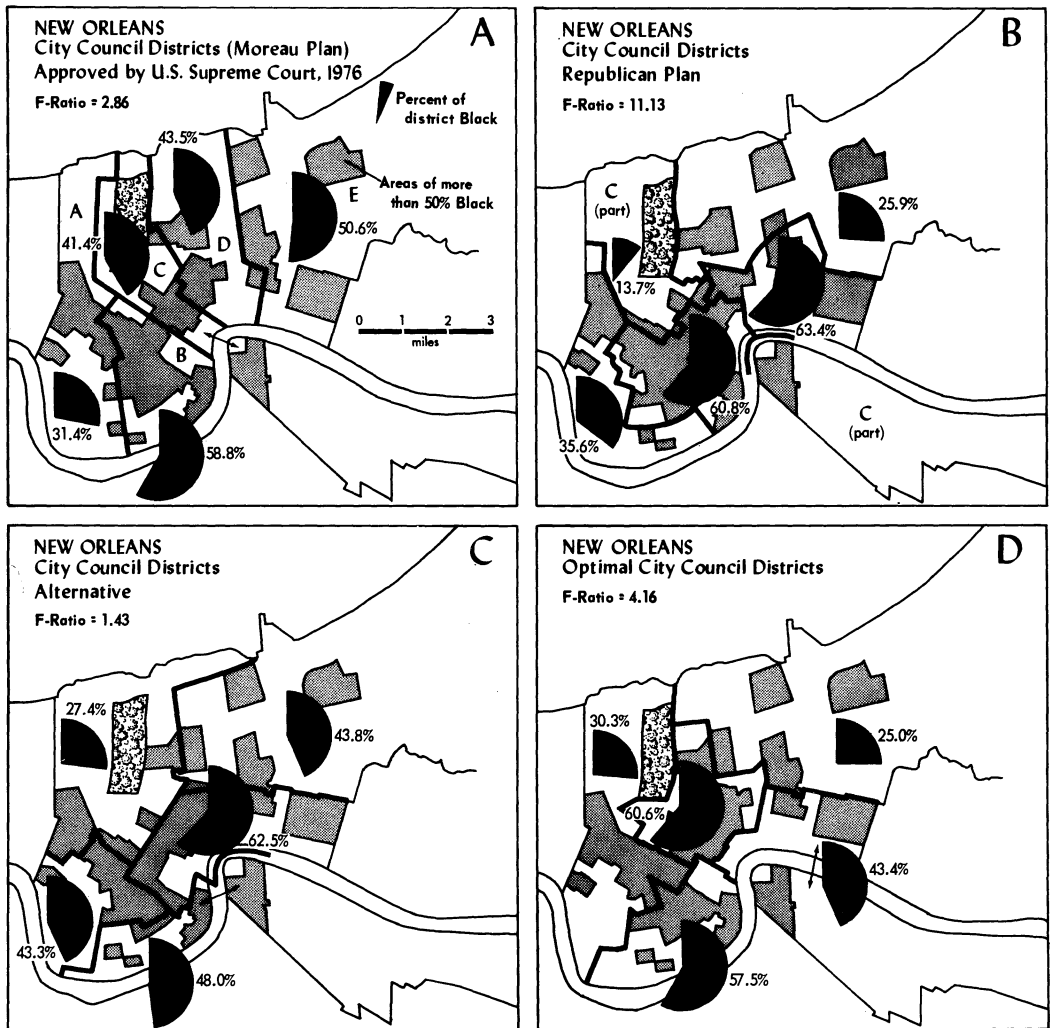
Figure 3. Actual and feasible city council districts, New Orleans, 1976.

the Moreau plan's position at the 76th percentile associated with the Z-score of +.72.

Eighty-one constitutional districting plans were generated in the present study. In all New Orleans districting litigation, the West Bank, that part of the city south of the Mississippi River and connected to the rest of the city by one bridge, always remained undivided. That precedent was followed in this study. Four plans suggested by interest groups were also evaluated. The optimal districting arrangement again was found in the modal category and produced two black-majority districts. Both districts also have black-registered majorities (Figure 3d). A districting solution with no black-majority dis-

trict was not created; the lowest F-ratio, 1.43, had one black district (Figure 3c). By far the highest F-ratio, 11.13, was derived for the plan suggested by the Orleans Parish Republican Party. It would have created two safe black districts in the middle of the city (Figure 3b). The Moreau plan accepted by the Supreme Court had two black-population-majority districts but only one with a black-registered majority (Figure 3a). Districts cutting across the grain of the black population concentration, like the Moreau plan, produced F-ratios smaller than 4.0. In almost all of these cases, only one district had a black-registered majority.

Sixty of the feasible districting plans had

F-ratios between 4.0 and 6.25 and clearly constitute modal choices (Figure 4). They contain two or three black-population-majority districts; 50 of the 60 contain two districts with black-registered majorities. The black plaintiffs and the Justice Department based their allegations on the presumption that a nonracial division of the city would produce two safe black districts. In fact, a feasible solution in which four districts have black majorities can be produced (Figure 4). Conversion from the F-ratio showed that the Moreau plan had a Z-score of -1.45, which placed it at the 7th percentile. Because the computed Z-score is less than the critical value of $Z = -1.28$ ($\alpha = .10$), the null hypothesis of no gerrymandering is rejected and the challenged plan is considered a racial gerrymander of the wasted-vote variety. Comparison of these results to Engstrom and Wildgen's shows that the Moreau plan, which they did not consider a gerrymander ($\alpha = .764$), is viewed here as diluting the black vote ($\alpha = .074$). We may view the comparison as showing that the odds of a plan less desirable to blacks is 7 in 10 by their computations and 7 in 100 by mine. Partial explanation of the different results can be attributed to the different data bases. Engstrom and Wildgen (1977) grouped the 411 electoral precincts into units on a 15-by-25 grid pattern; I used census tracts. They used registration figures to compute their polarization score; I used population figures. The computer algorithms were probably different, but it is impossible to state this as certain because Engstrom and Wildgen do not define their procedure. Differences between the two studies also appeared in criteria for constitutional solutions and the polarization scores. These differences point to the necessity for clear and objective evaluation procedures that can be used as standards by the courts. The justices have no wish to be embroiled in a battle of statistical experts concerning the superiority of different procedures. My computation of the Z-scores for other plans argued before the court showed results similar to Engstrom and Wildgen's. For the NAACP plan, their Z-score was $+0.97$ ($\alpha = .834$) and mine was $+0.69$ ($\alpha = .755$); for the Republican plan, Engstrom and Wildgen's Z-value was $+3.86$ ($\alpha = .0001$) and mine was $+4.38$ ($\alpha = .0001$). For the first redistricting rejected by the Attorney General, both studies conclude that it was a gerrymander. (Engstrom and Wildgen's computed $Z = 1.15$, $\alpha = .125$; mine had $Z = 2.497$, $\alpha = .006$).

This study of alleged black vote dilution in the New Orleans City Council districts reached the conclusion that, like the first plan rejected by the Attorney General, the Moreau plan also constituted a racial gerrymander. Although more beneficial to blacks than the first plan, the Moreau redistricting did not improve the situation enough to reach the threshold of modal choice. The plaintiffs, who argued that the issue was not relative progression or retrogression but absolute change, are supported by this study. The court's majority, while establishing the principle of nonretrogression, nevertheless viewed the creation of one black-vote-majority district sufficient to disprove the allegation of gerrymandering. The NAACP plan with three black population majorities constituted a modal and viable choice even though it contained only one district with a black voter majority (another district contained 46.0 percent black registered population). The Republican plan was a blatant attempt to create a benign gerrymander with two safe black seats. The procedure presented here could have helped clarify the issue of relative and absolute change for the justices and could have cleared some of the confusion accompanying the rival claims.
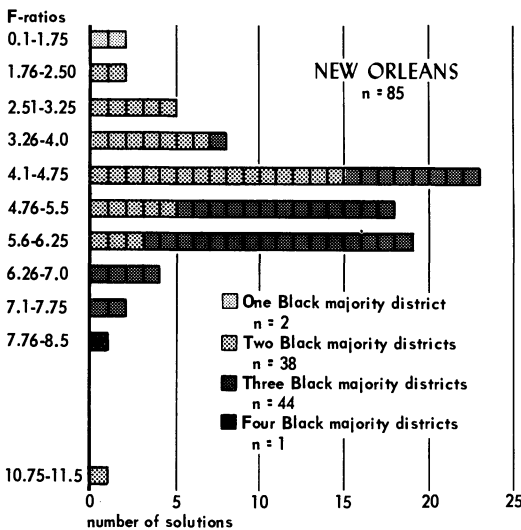

Figure 4. Distribution of F-ratios for New Orleans's feasible solutions.

Congressional Districts in Mississippi
(Connor v. Johnson 1967–1972)

Mississippi has been identified more frequently than any other state for black vote dilution. Obvious methods were ended by passage of the Voting Rights Act, but complex procedures continued to operate despite the presence in the state of federal inspectors (Washington Research Project 1972). The black population registered to vote in the state rose dramatically from 4 percent in 1956 to 33 percent in 1966. Black turnout is high, especially when a clear choice on the racial issue is offered to voters. In the 1960s, black population in Mississippi declined from 42 percent to 37 percent of the total, a trend continued in the 1970s. The consequences of this relative decline in black voters and population are far reaching; it is becoming easier to gerrymander the black population.

The black population is concentrated in the Mississippi Delta region in the western part of the state (Figure 5). Based on county data, the segregation index for blacks was 30.5 in 1960 and 28.7 in 1970. Moran's I statistic of spatial autocorrelation also showed a decline from .155 in 1960 to .144 in 1970 (Z = 12.64 in 1960; Z = 11.80 in 1970). Levels of concentration of the black population at the county level are far less than for blacks at the census-tract level in New York and New Orleans. Even without deliberate manipulation of the boundaries, numerous solutions to the districting problem would produce no black-majority district. This conclusion supports the maxim that minority voters distributed statewide are penalized heavily by the single-member district system.

Since the nineteenth century, congressional district lines had recognized the cultural split between the Delta and the hills in the northern part of Mississippi by a north-south delineation. Though blacks comprised a majority of the pre-1966 2nd district, they were not an electoral threat because of their tiny registration percentage (Figure 5a). Because of population deviations in excess of the 1964 standard, the state was redistricted along east-west lines in the northern part of the state (Figure 5, a and b). Despite numerous statements that the switch constituted a blatant attempt to prevent the election of a black, the plan was upheld by the local federal court and the appeal denied *certiorari* by the Supreme Court. This districting switch constitutes a clear test of the utility of the evaluation system proposed here. It would also seem to violate the "nonretrogression" principle adopted by the Supreme Court in *Beer v. United States* (1976).

Using 1960 census data, 49 feasible alternatives for five districts were generated in this study for the 82 counties of Mississippi. With random starting points, the algorithm converged rapidly to the optimal solution (Figure 5d). Six feasible solutions showed two black-majority districts, four solutions had no black-majority districts, and modal solutions clearly indicated one black district in the northwest corner of the state (Figure 6). Again the optimal solution fell into the modal category. The computed F-ratio for the pre- and post-1966 plans fell dramatically, from 13.92 in 1962 to 5.22 in 1966, reflecting the splitting of the black population concentration into three districts. The associated Z-scores were +1.05 (α = .15) for the 1962 apportionment and −1.35 (α = .08) for the 1966 plan. By any standard, this shift was a major retrogression for black electoral success. The 1966 plan falls below our critical value (Z = −1.29) for the definition of a wasted-vote gerrymander. There is little doubt that the result was planned, and this evidence clearly supports a presumption of gerrymandering. The onus should be placed on the state to justify the plan. Given Mississippi's long adherence to the Delta/hills cultural divide in its districting arrangement and the state's documented history of race discrimination, the chances of successful litigation by black plaintiffs would have been good. The inability of the court to separate the various dilution claims doomed this challenge to failure. It appears that the 1966 reapportionment will remain the basis for future Mississippi redistrictings.

To check the effects of black population decline and demographic trends in Mississippi on the districting arrangement, the 1970 census data were used to generate 42 feasible solutions. The histogram of outcomes showed a similar range of F-ratios but a dramatic increase in the number of solutions with no black-majority district, from 4 (out of 49) in 1960 to 13 (out of 42) in 1970. Black population losses have been greatest in the Delta, and fewer solutions produce a black-
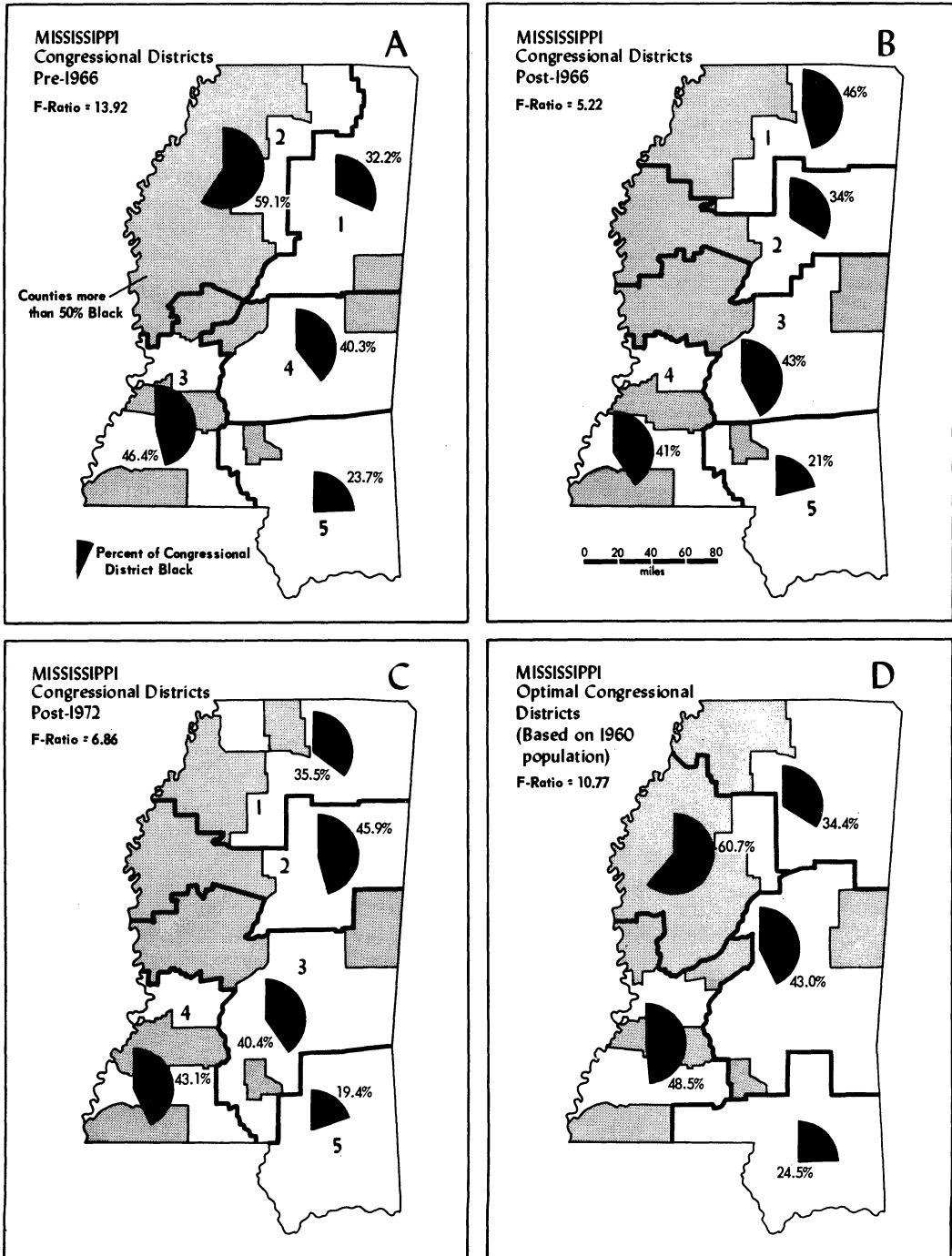
Figure 5. Actual and feasible congressional districts, Mississippi, 1962-1972.

F-ratios

MISSISSIPPI
Post-1960
Alternatives
n = 51

▦ Two Black
majority districts
n = 6

▨ One Black
majority district
n = 41

□ No Black
majority district
n = 4

F-ratios

MISSISSIPPI
Post-1970
Alternatives
n = 43

▦ Two Black
majority districts
n = 1

▨ One Black
majority district
n = 29
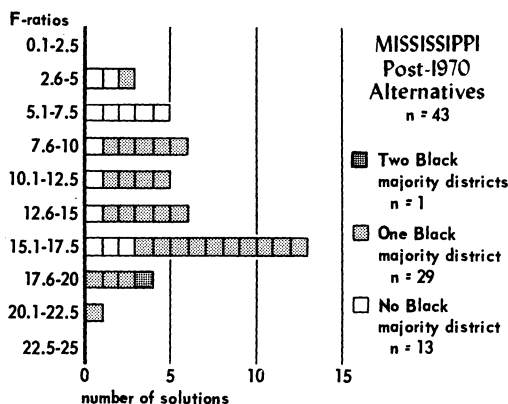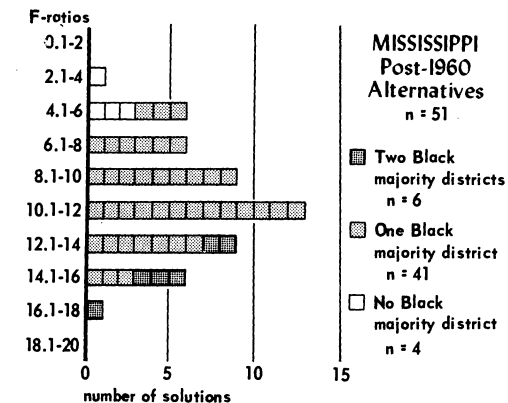
□ No Black
majority district
n = 13

Figure 6. Distribution of F-ratios for Mississippi's feasible solutions, 1960 and 1970.

majority district in that area. Nevertheless, the modal solution for Mississippi remained one black-majority district. The 1972 reapportionment plan had a Z-score of -0.93 ($\alpha = .18$) (Figure 5c). A probability of 0.18 of finding a plan less favorable to blacks does not support our previously defined assumption of gerrymandering, and this plan would pass constitutional muster. Demographic shifts in the state have moved the gerrymandered 1966 redistricting plan from the realm of discrimination into the zone of constitutionality. It is doubtful that a constitutional challenge to the 1966 plan would succeed at present. Section 5 of the Voting Rights Act was designed to prevent the retrogressive move of district boundaries (Figure 5, a and b). Such an obvi-

ous shift would almost certainly be denied permission for implementation today.

Conclusion

The current rash of legal challenges to reapportionments after the 1980 census raise anew the issue of proof of intentional discrimination in redistricting. The controversy surrounding congressional reapportionment will be greater than usual in states that are losing seats, as incumbents fight to retain their political strongholds, and in states gaining seats, where spatial allocation of new seats can add to either party's strength. At all levels of government, contemporary demographic and political trends favor Republicans, and in many Northern states any plan short of a pro-Democratic gerrymander will lead to a Republican majority. Previous lack of success has reduced the possibility of successful legal challenge on grounds of partisan bias. Knowing the costs and difficulty of a court case, most politicians hope for an electoral tide in their favor. Minority parties will try to reach a spatio-political compromise ensuring their strongholds before the redistricting plan is final. Coalitions in some states between blacks and Republicans to guarantee the continuation of black districts in inner cities constitute an example of political self-interest at the expense of white Democrats (Clymer 1981). Because Democrats cannot prove deliberate bias, these plans will probably go unchallenged.

Almost all gerrymander challenges will be on grounds of racial-vote dilution. Many commentators demand proportional representation for minorities. Unfortunately for their cause, residential concentration of black voters, low registration and turnout rates, and weak bargaining positions in legislatures work against this goal. Additionally, the Constitution does not guarantee group representation in proportion to group size. Consequently, most challenges will falter at the first step, and continued legal challenge will be devoted to local, individual district biases. Plaintiffs wish to show that a district line should go here and not there. By basing their arguments on a single district, plaintiffs are overlooking the possibility of challenging the

whole plan. The odds of success are increased if it can be shown that the challenged redistricting plan is an aberration within the framework of all feasible solutions to the districting problem. Before proceeding to legal research, use of the methods proposed in this paper can indicate the probability of occurrence of a plan more unfair to blacks, a powerful statistic in showing bias. Early computation of this probability could save time and money for plaintiffs. With the growing interest in nonpartisan redistricting, the techniques reported in this paper allow a neutral commission to perform a comparative evaluation of the impact of alternative redistrictings on parties and minorities. The final choice can therefore be justified more carefully.

A good example of the possible use of the districting approach advocated in this paper is the case of nonpolitical neutral districting for a court by an academic. A geographer, Richard Morrill, was appointed as a Special Master by the Federal District Court in Seattle to redistrict the state of Washington in 1972. His plans were accepted by the court and used in subsequent elections. He was hired for his technical, demographic, and geographic expertise. Morrill used "a manual, somewhat intuitive, patient experimental approach to draw the districts," although post-redistricting evaluation showed that better solutions could have been achieved using computer allocation methods (Morrill 1973, 1976). He was severely constrained by the courts in his district definitions, being subjected to a priority listing of criteria. Even using court-imposed constraints, a master could derive a large sample of constitutional plans in a short period of time and select that districting arrangement that achieved most or all of the court's objectives. Simultaneously, the master could defend this plan by comparing its impact on cognizable social and political groups, using the histogram procedure described earlier.

The spatial bases of representation have only recently been recognized by social scientists (Taylor and Johnston 1979). Understanding of the connection between the residential distribution of voters and their representation has provided a breakthrough in explanation of the Cube Law, in defining the components of electoral bias, and in accounting for variations in the well-established relationship between social class and party choice. Development of a theoretical model linking voter spatial distribution and representation is a route that political geographers could follow profitably. By simulating the voting surface and defining a large sample of alternative ways in which this surface can be divided into districts, we could establish the theoretical relationship between representation and spatial distribution of voters. In an actual districting case, given the spatial distribution of the target group, we could predict a priori the histogram of impact scores and the optimal, modal, and worst districting solutions for this group. If proportional representation is a redistricting criterion, solutions that guarantee this aim are clearly identified. Many observers and participants in redistricting struggles fail to understand why seat proportions frequently do not equal vote proportions for minority parties and groups. A focus on the underlying spatial causes of this mismatch and the possible ways of circumventing the tyranny of space by geographers would be an enormous contribution to the representation debate currently under way in the courts and newspapers and among academics of this nation.

Acknowledgments

References

Adams, B. 1977. Model state reapportionment process: the continuing quest for "fair and effective" representation. *Harvard Journal on Legislation* 14:825–904.

Backstrom, C., Robbins, L., and Eller, S. 1978. Issues in gerrymandering: an exploratory measure of partisan gerrymandering applied to Minnesota. *Minnesota Law Review* 62:1121–59.

Baker, G. 1971. Gerrymandering: privileged sanctuary or next judicial target. In *Reappor-*

tionment in the 1970s, ed. N. W. Polsby, pp. 121–50. Berkeley: University of California Press.

Bailey, R., ed. 1980. *Black people and the 1980 census,* Vol. 1. Chicago: Illinois Council for Black Studies.

Berry, B. J. L., and Dye, T. R. 1979. The discriminatory effects of at-large elections. *Florida State University Law Review* 7:85–122.

Clymer, A. 1981. Redistricting proving as troublesome to growing states as to shrinking. *New York Times,* July 21, p. 88.

Craig, W. J. 1973. Reapportionment and the computer. *Law and Computer Technology* 6:50–56.

Derfner, A. 1980–1981. Pro affirmative action in districting. *Policy Studies Journal* 9, Special Issue no. 3:851–862.

Edwards, J. M. 1971. The gerrymander and "one man, one vote." *New York University Law Review* 46:879–99.

Ely, J. H. 1970. Legislative and administrative motivation in constitutional law. *Yale Law Journal* 79:1205–1341.

Eisenberg, T. 1977. Disproportionate impact and illicit motive: theories of constitutional adjudication. *New York University Law Review* 52:36–171.

Engstrom, R. L., and Wildgen, J. K. 1977. Pruning thorns from the thicket: an empirical test of the existence of racial gerrymandering. *Legislative Studies Quarterly* 2:465–79.

Gaile, G. L. 1977. Effiquity: a comparison of a measure of efficiency with an entropic measure of the equality of discrete spatial distributions. *Economic Geography* 53:263–82.

Goodchild, M. F. 1973. LAP-location-allocation package. In *Computer programs for allocation problems,* ed. G. Rushton, M. F. Goodchild, and L. M. Ostresh, pp. 85–113. Iowa City: Department of Geography, University of Iowa, Monograph no. 6.

Gudgin, G., and Taylor, P. J. 1974. Electoral bias and the distribution of party voters. *Transactions, Institute of British Geographers* 63:53–74.

———. 1979. *Seats, votes and the spatial organization of elections.* London: Pion Limited.

Halpin, S. A., Jr., and Engstrom, R. L. 1973. Racial gerrymandering and southern state legislative redistricting: attorney general determinations under the voting rights act. *Journal of Public Law* 22:37–66.

Hatcher, R. 1969. The black role in urban politics. *Current History* 31:287–89, 306–07.

Jenkins, M. A., and Shepherd, J. W. 1972. Decentralizing high school administration in Detroit: an evaluation of alternative strategies of political control. *Economic Geography* 48:95–106.

Johnston, R. J. 1979. *Political, electoral and spatial systems.* Oxford: Clarendon Press.

Lewis, P. F. 1976. *New Orleans: the making of an urban landscape.* Cambridge, Mass.: Ballinger Publishing Company.

Lijphart, A. 1980–1981. Comparative perspectives on fair representation: the plurality-majority rule, geographical districting, and alternative electoral arrangements. *Policy Studies Journal* 9, Special Issue No. 3:899–915.

Morrill, R. L. 1973. Ideal and reality in reapportionment. *Annals of the Association of American Geographers* 63:463–77.

———. 1976. Redistricting revisited. *Annals of the Association of American Geographers* 66:548–56.

———. 1981. *Political districting and geographic theory.* Washington: Association of American Geographers, Resource Publications in Geography.

Niemi, R., and Deegan, J., Jr. 1978. A theory of political districting. *American Political Science Review* 72:1304–23.

O'Loughlin, J. 1976. Malapportionment and gerrymandering in the ghetto. In *Urban policymaking and metropolitan dynamics: a comparative geographical analysis,* ed. J. S. Adams, pp. 539–565. Cambridge, Mass.: Ballinger Publishing Company.

———. 1980. The election of black mayors, 1977. *Annals of the Association of American Geographers* 70:353–70.

Prescott, J. R. V. 1972. *Political geography.* New York: St. Martins Press.

Pulsipher, A. S. 1973. Empirical and normative theories of apportionment. *Annals, New York Academy of Science* 219:234–41.

Rosenzweig, A., and Wildgen, J. K. April 1978. A statistical analysis of the 1977 mayor's race in New Orleans. *Louisiana Business Survey* 9:4–8.

Rossiter, D. J., and Johnston, R. J. 1981. Program GROUP: the identification of all possible solutions to a constituency-delimitation problem. *Environment and Planning A* 13:231–238.

Taylor, P. J. 1973. A new shape measure for evaluating electoral district patterns. *American Political Science Review* 67:947–50.

———. 1974. Electoral districting algorithms and their applications. Paper presented at a meeting of the Quantitative Methods Study Group of the Institute of British Geographers, Norwich, January 1974.

Taylor, P. J., and Johnston, R. J. 1979. *Geography of elections.* Harmondsworth, Middx: Penguin Books.

Tufte, E. R. 1973. The relationship between seats and votes in two-party systems. *American Political Science Review* 67:540–54.

Van Valey, T. L., Clark, W. C., and Wilcox, J. E. 1977. Trends in racial segregation, 1960–1970. *American Journal of Sociology* 82:826–44.

Washington Research Project. 1972. *The shameful blight: the survival of racial discrimination in voting in the South.* Washington: Washington Research Project.

Weiner, P. H. 1977. Boundary changes and the power of the vote. *University of Detroit Journal of Urban Law* 54:959–1023.

Wells, D. 1980–1981. Con affirmative gerrymandering. *Policy Studies Journal* 9, Special Issue no. 3:863–74.

Wildgen, J. K., and Engstrom, R. L. 1980. Spatial

distribution of partisan support and the seats/votes relationship. *Legislative Studies Quarterly* 5:423–35.

Wollock, A. J., ed. 1980. *Reapportionment: law and technology*. Denver: National Conference of State Legislatures.

Cases Cited

Gomilion v. Lightfoot. 1960. 364 U.S. 339.
Baker v. Carr. 1962. 369 U.S. 186.
Reynolds v. Sims. 1964. 377 U.S. 533.
Wright v. Rockefeller. 1964. 376 U.S. 52.
Fortson v. Dorsey. 1965. 379 U.S. 433.

Connor v. Johnson. 1966. 279 F. Supp. 619 (S.D. Miss).
South Carolina v. Katzenbach. 1966. 383 U.S. 301.
Harper v. Virginia Board of Elections. 1966. 383 U.S. 663.
Kirkpatrick v. Preisler. 1969. 394 U.S. 526.
Wells v. Rockefeller. 1969. 394 U.S. 542.
Whitcomb v. Chavis. 1971. 403 U.S. 124.
Bullock v. Carter. 1972. 405 U.S. 134.
Mahan v. Howell. 1973. 412 U.S. 735.
Gaffney v. Cummings. 1973. 412 U.S. 735.
White v. Regester. 1973. 412 U.S. 755.
Beer v. United States. 1976. 425 U.S. 130.
Washington v. Davis. 1976. 426 U.S. 229.
Arlington Heights v. Metropolitan Housing Corporation. 1977. 429 U.S. 252.
United Jewish Organizations of Williamsburgh v. Carey. 1977. 430 U.S. 144.
City of Mobile v. Bolden. 1980. 48 U.S.L.W. 4436.