SIMULATION OF GRS FORMULA ALTERNATIVES*

by

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The State and Local Fiscal Assistance Act of 1972 (Public Law 92-512) established the program known as General Revenue Sharing (GRS) to redistribute to state and local governments a portion of Federal revenues from individual income taxes. About 39,000 recipient governments will have received an aggregate of $30.2 billion by the time the current legislation expires in December 1976. Eligible recipients include all state, county, municipal, and township governments, other general purpose governments as determined by the Bureau of Census, and certain Indian tribes and Alaskan native villages. Neither special districts nor school districts are direct recipients of GRS funds.

GRS funds were appropriated for seven entitlement periods. Entitlements to recipient governments are determined for each period on the basis of an allocation formula specified in the Act, as it has been implemented by the Office of Revenue Sharing.

The National Science Foundation funded several studies including our own, that were directed toward developing and evaluating alternative allocation formulas that would achieve one or more specified policy goals better than the current formula. The two major goals chosen by SRI were:

(1) Allocation of funds among local governments according to the magnitude of their responsibilities and functions.

(2) Allocation of funds to provide most assistance to local jurisdictions with the greatest needs.

Other factors that were considered in the development and evaluation of alternatives included:

- Reduction of the degree to which allocations are determined by limits and complex decision rules.
- Alternative methods of allocating to Indian tribes and Alaskan native villages.
- Reduction of the fluctuations in entitlements across entitlement periods.
- Availability of current, accurate data.

In the next section the current allocation procedure is described. This is followed by a description of the general method of approach and the computational approach developed to simulate the ORS allocation software. In the final section, some of the major results are described. More details regarding our study are available in our final report (1).

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The GRS Allocation Formula

The allocation procedure consists of a sequence of steps in which GRS funds are distributed among state-areas, among county-areas within each state, and finally among local governments within each county-area.

The allocation formulas are presented in algebraic form in a U.S. Bureau of the Census publication (2). We will give a verbal description here to acquaint the reader with the terminology and the sequence of the allocation procedure. The allocation process is described schematically in Figure 1.

State-Area Allocation Process

Allocations are made among the 51 state-areas (50 states and the District of Columbia) according to a three-factor formula and a five-factor formula called respectively the Senate and House formulas. The higher of the two amounts is selected for each state and then scaled so that the total allocation equals the appropriation for any particular entitlement period.

The three-factor formula is multiplicative. The product of population, the relative income factor (the reciprocal of per capita income), and the general tax effort factor (tax revenue divided by total personal income) is computed for each state-area. The amount allocated to each state under this formula is proportional to this product.

The five-factor formula is additive. The total amount to be allocated is divided into five parts and each part is allocated separately on the basis of five different factors: 22% in proportion to population; 22% in proportion to urbanized population; 22% in proportion to population divided by per capita income; 17% in proportion to the state income tax amount; and 17% in proportion to tax revenue weighted by general tax effort.

If either Alaska or Hawaii uses the three-factor formula, an adjustment to the state-area allocation is made from a separate fund appropriated for this purpose ($4.78 million on an annual basis).

County-Area Allocation Process

One-third of the state-area allocation is apportioned to the state government with the remaining two-thirds going to all local governments. The amount going to all local governments is divided among county-areas in proportion to the three-factor formula: the product of population, the relative income factor, and the general tax effort factor.

The amount allocated to all local governments (two-thirds of the state-area allocation) divided by the population of the State is called the per capita local share. No county-area may receive per capita more than 145% or less than 20% of the per capita local share. The 145% constraint is applied first and any resulting surplus is shared

proportionately by the county-areas within the state that are not 145% constrained. The 20% constraint is then applied to those not 145% constrained. Any resulting deficit is made up proportionately from county-areas among these that are above the 20% limit.

Local Government Allocation Process

At this stage, each county-area allocation is divided among local governments and Indian tribes within the county-area. The per capita allocation to each recipient Indian tribe and Alaskan native village is identical to the per capita allocation for the county-area. That is, each tribe and village receives a portion of the county-area allocation in proportion to its population.

The remaining county-area funds are divided among types of local government (counties, places, and townships) in proportion to the adjusted taxes attributed to each type. Allocations are made among recipients of the same type--townships or places--on the basis of the three-factor formula. The product of population, the relative income factor, and the general tax effort factor is computed for each government and allocations are made in proportion to the product.

At the local level, four constraints or limitations are applied: (1) no place or township may receive per capita more than 145% of the per capita local share; (2) no place or township may receive per capita less than 20% of the per capita local share; (3) no local government may receive an allocation that is more than 50% of its budget as measured by the sum of adjusted taxes and intergovernmental transfers; and (4) no local government may receive less than $200 on an annual basis.

The 145% and the 20% constraints are applied first. If the allocation to a township or place is above the 145% limit, it is decreased to the limit; if the allocation is below the 20% limit, it is raised to either the 20% limit or the 50% limit, whichever is lower.

The 50% limit is next applied. It is first applied to townships and places and any excess accrues to the county government. The county government is then subjected to the limit and any excess accrues to the State government.

Finally, if any allocation is less than $200, or any unit of local government waives its entitlement, the funds are allocated to the next higher eligible level of government (either county or state).

The Iteration Procedure

Because of the way the 145% and 20% per capita limits are applied to townships and places, it is possible that the sum of all amounts allocated within a State will not correspond to the state-area allocation. In such a case, an adjustment is made in the amount going to local governments and the process of allocating to local governments is repeated until the amounts allocated total 100% of the state-area entitlement.

Method of Approach

The study approach adopted by SRI recognized the current GRS formula as the product of a serious effort to reflect the Congressional intent to direct funds to recipient governments in accordance with their responsibilities and needs. Rather than starting de novo, therefore, we took the current formula as a baseline and identified components that appeared to warrant modification.

The candidate alternative components were initially proposed on the basis of a priori criticisms of the current formula. For example, we proposed to loosen the constraints on per capita allocations to county areas and local governments in order to enhance the redistributive effects of the formula. The 20% lower bound appeared to overreward many governments that had low activity and were considered by many to be archaic; the 145% upper bound had the effect of denying funds to some large central cities that were under extreme fiscal pressure.

The allocation software, as described in the next section, was developed to simulate allocations under the current and alternative allocation formulas. Six states--California, Colorado, Delaware, Louisiana, Massachusetts, and Missouri--had been selected for the initial analyses. The current and alternative allocations were made for these six states and were described in a series of SPSS-generated tables that included:

- Distribution of allocations among state and local governments categorized by government type, population size, and per capita income.
- Amounts of funds transferred among units of government under the alternative.
- Distribution of local government units with respect to percent change in allocations from the current under each alternative.
- Percent change in allocations from the current formula under each alternative for government categorized by indices of constituency need (per capita income) and government responsibility (per capita adjusted expenditures).

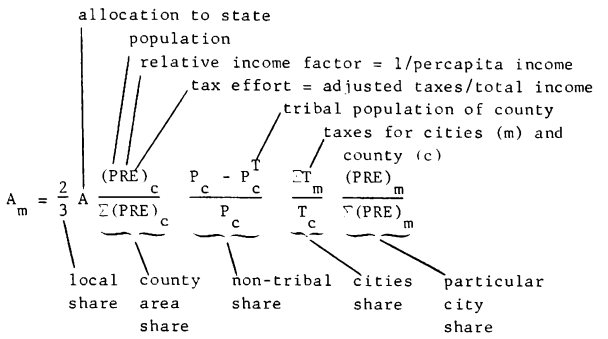
In addition, lists of outliers--governments with extremely low or high per capita allocations or extremely high changes in allocation--were generated for each alternative. Our approach was less structured than that of other studies funded by NSF. A summary of all the NSF-sponsored studies is available in (3). Some of these studies established a distribution of GRS funds that could be considered "ideal" and sought an alternative allocation formula that came closer to the ideal distribution than the current formula yet was capable of being implemented. Another approach was to establish a criterion measure, usually related to parameters in a regression model, and then to select the alternative that appeared to maximize the criterion measure.

After a detailed examination of the current intrastate formula, twelve components were identified that we felt merited consideration for change. Several alternative modifications were initially considered for each component. After the simulated impact of each individual modification was evaluated, it was either discarded or retained for inclusion in a composite alternative. The composites were then formulated and also subjected to evaluation. From this process, a preferred alternative formula was derived. Finally, a national allocation run was made under the preferred alternative to verify that the results found for the six sample states generalized to the entire United States.

Computational Approach

As a background to the issue of computation, we will discuss briefly the arithmetic of the present intrastate

allocation process. If no constraints are applicable at any level of government in a state, it is a simple matter to write the allocation to a city m (for municipality). The formula is



where

$(PRE)_c$ means $P_c R_c E_c$ and similarly for $(PRE)_m$,

$\Sigma (PRE)_c$ is taken over all counties in the state

and

ΣT_m and $\Sigma (PRE)_m$ are taken over all cities in the county.

Similar formulas can be written for townships, county governments and Indian tribes and Alaskan native villages.

During the course of our work for the Office of Revenue Sharing (4) we observed a fact about the allocation procedure that had not been previously noted: When constraints are operative in a state (as is nearly always the case) there exists a constant k for the state such that the allocation to an unconstrained recipient in an unconstrained county area is equal to k times its allocation as determined from the formula above (or from its analog for types of recipients other than cities). Moreover, if a recipient, say a city, is in an unconstrained county and kA_m is within the per capita constraints for the city, then that is its allocation. Formulas in constrained county-areas and constrained recipients are even easier to write out.

The factor k is itself the product of two factors k_C and k_L; the first is associated with meeting county-area per capita constraints, the second with meeting the local government per capita constraints. For a given value of k_L, an iterative process that involves county-area data only is used to determine k_C. Then, with $k = k_L k_C$, the local government allocations are calculated and trimmed to fit per capita constraints. The total amount so allocated is compared with the amount that was to be allocated and a new value of k_L is determined. These iterations that determine k_L are called state-level iterations. They terminate when the amount actually allocated and the amount to be allocated differ by less than one dollar. This accuracy is easily attainable, because the curve of amount allocated versus k_L is a sequence of line segments.

Clearly, a basic requirement of our study was to have available a computer program that would be capable of carrying out these computations for both the current procedure and for the various alternatives as well. A version of the current revenue sharing procedure written in Fortran was available. However, in our opinion this program, which was closely patterned after the program developed by the Office of Revenue Sharing, was not suitable for the computations we wished to perform; run costs were anticipated to be of the order of $60 per state. We had already written a program for the SRI Data Study that did most of the allocation computations, although it did not perform iterations; the k's were inputs. Certain that this program would perform much more quickly than the available software, we exhumed it and embroidered onto it the required iterative aspects. The results could hardly be believed. The cost per state was more like 60 cents.

The improvement resulted from replacing a program that cycled recipient data on tape or disk through the computer for each of the four to six iterations by an all-in-core version. Other economies were made too, principally by (1) moving as many computations as possible outside of the iterative part of the program (2) carrying out the computations in per capita form thus saving a very large number of counteracting divisions and multiplications, and (3) recognizing that since application of the 50% rule does not affect the total amount actually allocated, it is not necessary to apply that limitation until the state-level iterations have converged. In view of this, it was not surprising that our software was more efficient, but we were astonished at the level of improvement. Documentation and a listing of the program are available from SRI (5).

The compressed nature of our procedure had some drawbacks when it came to adapting it for calculating the alternatives. As an example, county population is used in several places in the formula quoted above: in the three-factor for allocating to county-areas, in the formula for determining per capita allocation to the county-area, and in the formula for allocating to tribal units. If an alternative required replacing population by some other factor, care had to be taken to replace it only in the occurrences desired--typically not in its use for allocating to tribal units.

Also, Illinois caused some strain to the all-in-core approach. It has nearly 3000 recipients and required that the storage array for recipient data be 30,000 words in length.

Results

From an initial list of over 25 possible modifications of the current formula, eight were retained for inclusion in a composite. From these eight individual components, six composite alternatives were created and evaluated with respect to attaining the formula goals. In Table 1, the eight alternative components are listed and the six composite formulas are described with respect to the components they include. Based on comparisons of the degree to which each composite achieved the formula goals selected by SRI, as well as for a number of operational and practical reasons, Composite C2 was chosen as the preferred alternative.

This alternative raises the upper per capita allocation limit to 300% and eliminates the 20% lower limit. It also reduces the budget limit from 50% to 20% of adjusted revenues plus intergovernmental transfers. The sequence of allocations is modified so that Indian Tribes and Alaskan native villages receive their allocations at the national or state level, rather than the county-area level. The county-area step in the allocation procedure is eliminated so that units of government of the same type compete among themselves across each state. Finally, an adjusted revenue measure was substituted for adjusted taxes.

Table 1

SRI PREFERRED FORMULA COMPONENTS

Description of Alternative Component	Single Change	Composite Change C1	C2	C3	C4	C5	C6
Raise upper per capita local share constraint from 145% to 300% and eliminate 20% lower per capita local share constraint	X	X	X	X	X	X	X
Lower 50% budget constraint to 20% of adjusted taxes and intergovernmental transfers and in composite version substitute adjusted revenues for adjusted taxes	X	X	X	X	X	X	X
Modify the hierarchical procedure to allocate to local governments by type (counties, places, etc.) directly from the state level, calculating a separate per capita local share constraint for each class			X		X		X
Modify the State-local split to be based on the ratio of State government direct expenditures to general and special purpose local government direct expenditure	X					X	X
Allocate to Indian tribes and Alaskan native villages directly from the Federal or state levels	X		X		X		X
Substitute adjusted expenditures for population as the measure of governmental responsibilities and functions	X			X	X	X	X
Substitute adjusted revenues for adjusted taxes as the measure of own efforts to satisfy need	X	X	X	X	X	X	X
Include special and school district taxes (revenues in the composite) in the county area adjusted revenues definition	X	X		X		X	

There was a pronounced impact on allocations. Practically every large central city gained substantially under this alternative (see Table 2). Allocations to most county governments and small municipalities decreased. About 90% of the county governments nationwide would lose 10% or more of their current allocations. GRS funds going to low-activity Midwestern townships and New England townships were also reduced sharply. For example, 98% of the townships in Illinois would have lost 25% or more of their current allocations. The reduction of the budget limit to 20% had the effect of transferring funds from relatively inactive local governments to the state government in many states.

The substitution of adjusted revenues for adjusted taxes was made because adjusted taxes did not include many sources of revenue, such as current changes and special assessments, that are used by many units of local government. The major impact of incorporating this component was that the allocations to county governments almost universally decreased because county governments tend to rely on taxes more than other types of governments.

Generally, relatively active central cities and state governments had increases in allocations at the expense of relatively less active local governments. This alternative also appeared to be somewhat more redistributive than the current formula with respect to the per capita income of the constituents. This preferred formula appeared to be relatively better at rewarding high-responsibility high-need governments than either the current formula, or other alternatives evaluated by SRI. It was also attractive because it is immediately operational with respect to data requirements with small incremental cost.

REFERENCES

1. Reese C. Wilson, David H. Kaskowitz, William C. Grindley, and Donato A. D'Esopo, "General Revenue Sharing Formula Alternatives," Stanford Research Institute, Menlo Park, California (1975).
2. U.S. Bureau of the Census, Census Tract Papers, Series GE-40, No. 10, "Statistical Methodology of Revenue Sharing and Related Estimate Studies," pp. 37-41, U.S. Government Printing Office, Washington, D.C. (1974).
3. National Science Foundation, "General Revenue Sharing Research Utilization Project, Volume 1: Summaries of Formula Research," U.S. Government Printing Office, Washington, D.C. (1975).
4. Reese C. Wilson, W. C. Grindley, R. Davis, et al., "General Revenue Sharing Data Study," Stanford Research Institute and Technology Management Incorporated, Menlo Park, California (1974).
5. D. A. D'Esopo, "The SRI Version of the Intra-State Revenue Sharing Procedure," Stanford Research Institute, Menlo Park, California (1975).

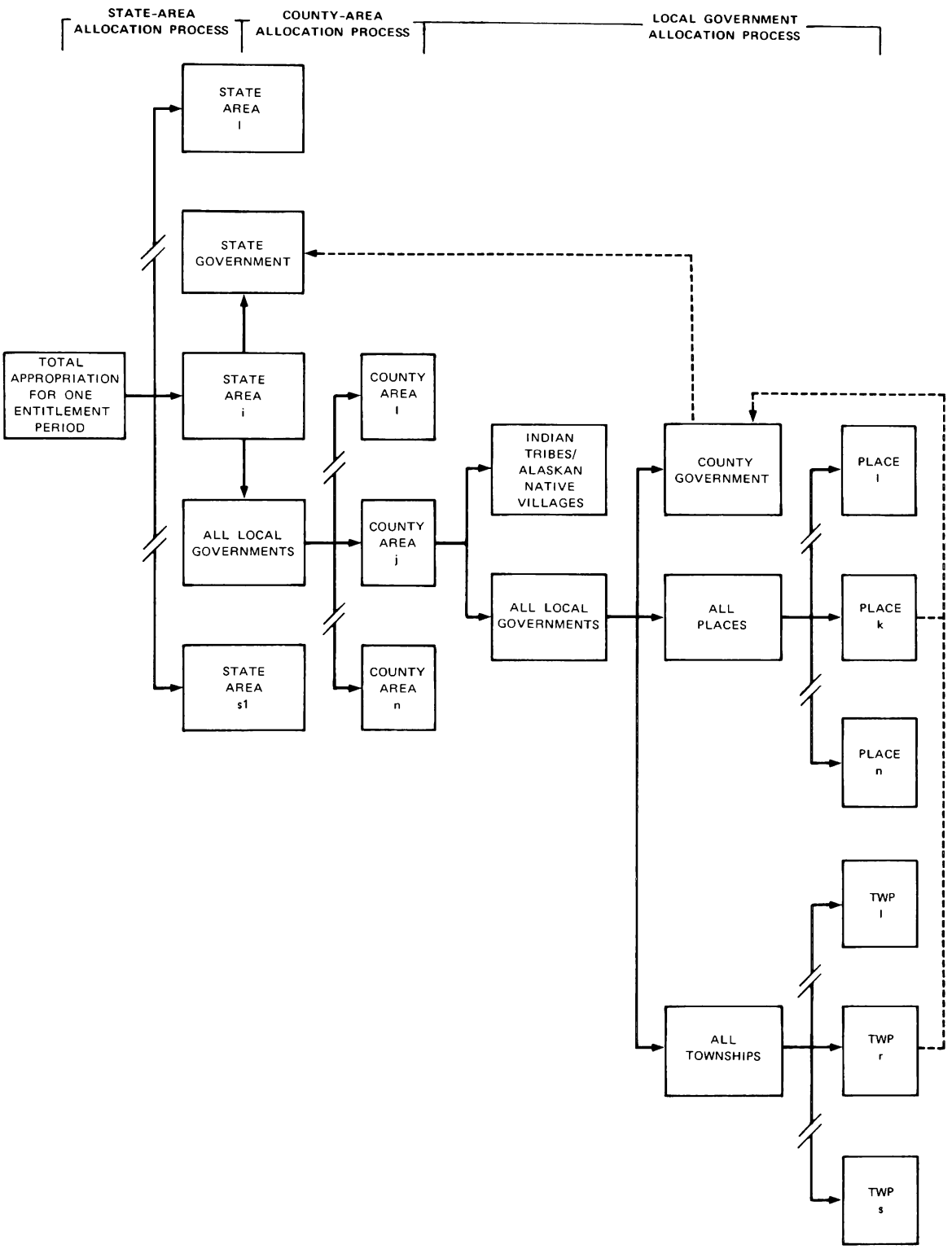


FIGURE 1 GRS ALLOCATION PROCESS

Table 2

ALLOCATIONS TO THE 51 MOST POPULOUS CITIES--ENTITLEMENT PERIOD 4

City	Current Formula	Preferred Alternative (C2)	Percent Difference
Birmingham, Ala.	$ 6,980,137	$ 9,402,221	34.7%
Phoenix, Ariz.	9,296,239	9,959,958	7.1
Oakland, Calif.	5,035,407	4,831,969	-4.0
Long Beach, Calif.	3,362,126	3,945,973	17.4
Los Angeles, Calif.	35,370,285	38,884,751	9.9
San Diego, Calif.	6,837,114	10,843,989	58.6
San Francisco, Calif.	19,358,810	30,305,292	56.5
San Jose, Calif.	4,761,198	5,820,844	22.3
Denver, Colorado	13,088,128	17,130,847	30.9
Washington, D.C.	18,100,035	18,100,035	.0
Miami, Fla.	7,968,192	8,867,513	11.3
Jacksonville, Fla.	9,160,050	7,107,452	-22.4
Tampa, Fla.	5,851,190	6,942,460	18.7
Atlanta, Ga.	7,158,095	10,559,581	47.5
Honolulu, Hawaii	13,253,171	15,838,186	19.5
Chicago, Ill.	68,459,106	78,155,271	14.2
Indianapolis, Ind.	12,094,439	14,080,722	16.4
Louisville, Ky.	10,695,220	17,301,307	61.8
Baton Rouge, La.	7,864,383	9,086,586	15.5
New Orelans, La.	17,956,561	24,085,558	34.1
Baltimore, Md.	26,461,399	25,993,150	-1.8
Boston, Mass.	20,784,623	25,025,719	20.4
Detroit, Mich.	42,077,459	52,493,026	24.8
Minneapolis, Minn.	6,291,059	8,612,145	36.9
St. Paul, Minn.	5,134,396	6,634,363	29.2
Kansas City, Mo.	11,688,321	12,838,294	9.8
St. Louis, Mo.	14,376,973	19,726,853	37.2
Omaha, Neb.	5,237,218	5,868,590	12.1
Newark, N.J.	9,258,226	11,714,309	26.5
Buffalo, N.Y.	7,494,054	7,812,257	4.2
Rochester, N.Y.	3,167,825	4,397,605	38.8
New York, N.Y.	253,803,141	291,234,837	14.7
Cleveland, Ohio	13,641,584	22,700,197	66.4
Columbus, Ohio	7,575,425	9,085,010	19.9
Cincinnati, Ohio	9,726,139	12,816,943	31.8
Toledo, Ohio	5,132,082	5,943,037	15.8
Oklahoma City, Okla.	6,389,444	7,819,720	22.4
Tulsa, Okla.	5,548,595	5,413,040	-2.4
Portland, Ore.	9,008,185	10,449,858	16.0
Pittsburgh, Pa.	13,365,649	13,239,530	-.9
Philadelphia, Pa.	50,109,806	76,089,277	51.8
Nashville-Davidson, Tenn.	8,422,129	12,326,756	46.4
Memphis, Tenn.	11,838,104	15,073,461	27.3
San Antonio, Tex.	9,621,627	12,876,056	33.8
Dallas, Tex.	13,614,048	14,415,805	5.9
El Paso, Tex.	6,171,062	7,130,130	15.5
Houston, Tex.	18,009,268	16,842,883	-6.5
Fort Worth, Tex.	5,266,630	6,467,001	22.8
Norfolk, Va.	7,556,488	8,809,213	16.6
Seattle, Wash.	8,709,208	10,974,921	26.0
Milwaukee, Wis.	12,839,417	17,874,327	39.2