Techniques of Data Analysis and Presentation for Planners of the Metropolitan Environment

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ABSTRACT.—Relationships between the characteristics of the physical environment of a metropolitan area and the activities of its human inhabitants can be used to predict probable future dynamic trends, both demographic and environmental. Using simple linear regression, we were able to highlight several dynamic features of the metropolitan area of Tulsa, Oklahoma. Computer movies of the growth of Tulsa and attendant air-pollution problems were used for showing demographic and physical features simultaneously to facilitate the information-assimilation process so critical to planning.

THE NEED FOR ASSIMILATION of large quantities of data is critical to decision-makers in metropolitan environmental planning. The rapid and effective transfer of technology from the scientific and engineering fields to the urban-planning field is the purpose of the studies presented in this paper.

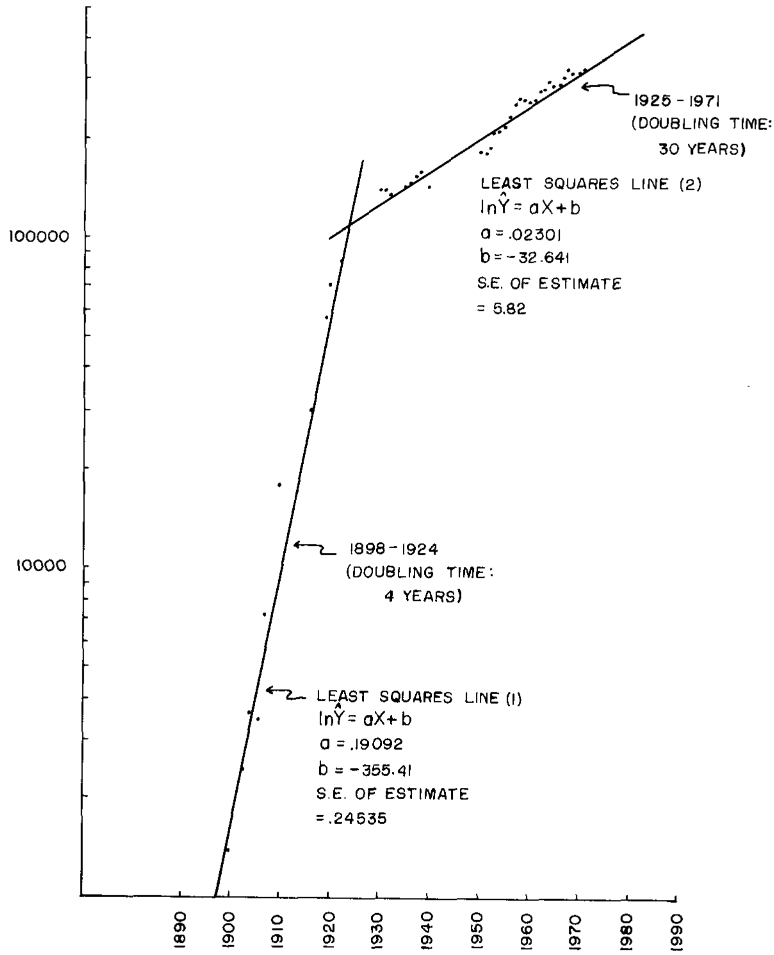
ANALYSIS OF THE GROWTH OF TWO CITIES

The understanding of past and present dynamic trends is required for successful urban planning if we are to make future growth more orderly and less chaotic, more useful to mankind and less wasteful of resources. Improving communication between disciplines that already make wide use of analytical tools and those just beginning to make use of such tools for solving problems of human settlement provided the impetus for a study. An attempt was made to collect data from the metropolitan areas of Oklahoma City and Tulsa, Oklahoma, which represent a 100-year time span (fig. 1). These data were the basis of an analysis and comparison of the growth trends in these two cities *(Normand 1975)*. The analysis technique used was that of regression of the data on time. Efforts to plot the data on a linear graph produced the usual poor fit to a straight line; however, when regression was performed on the log of the data, results represent familiar growth curves (fig. 2 and 3).

The analysis produced some interesting highlights of the characteristics of the two cities. For example, the consumption of electricity in Tulsa doubles every 8 years while the population has doubled only every 30 years since about 1922. The fact that Tulsa continues its use of electrical power at a rate almost four times faster than that of population growth points out a higher per-capita use of power at an ever-increasing rate. In both cities the population growth rate changed drastically in the 1920s. Tulsa's population doubled about every 4 years until 1922, then changed rate and has since doubled every 30 years. Oklahoma City's rate changed from a doubling time of 7 years to 30 years.

Such a change is attributed by some to oil boom years. However, the difference in character of the two cities is much better illustrated by graphs on economic indicators and employment. The highlights of population growth versus energy consumption illustrate a fast-approaching time when decisions will have to be made on proper resource allocation on a private and public scale.

Figure 1.—Population growth of Tulsa, Oklahoma. Regression of log Y on X.



This type of study could perhaps remove some barriers to interdisciplinary communication and utilization of analytical techniques in a practical application in metropolitan/environmental planning.

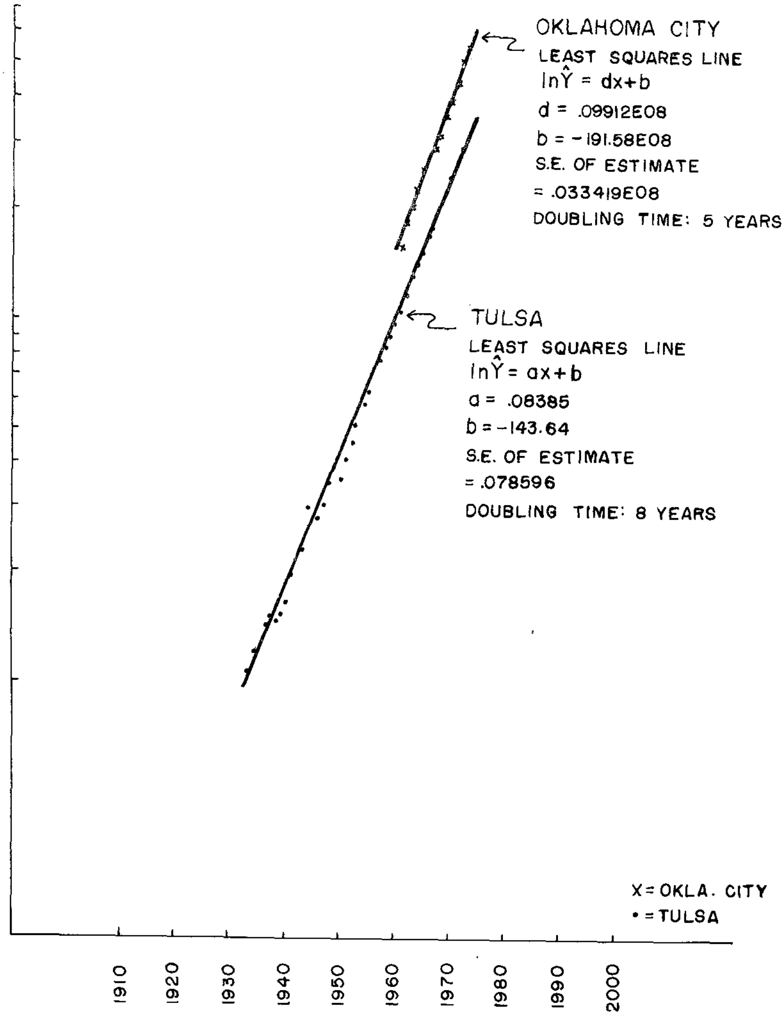
COMPUTER MOVIE OF THE GROWTH OF TULSA

In a text used by students of urban planning it is stated that "planners are ultimately interested in making statements about the relationships between key variables as they may or should exist at some future time. In order to make such statements, planners study the past and present conditions of the factors relevant to a given situation" (Goodman and Freund 1968).

Visualizing the evolution of the metabolism of a city is required in order to understand the character of its growth in the past and to plan for its future. With this idea in mind, data were collected from several metropolitan areas in Oklahoma for use in analysis of past and present trends, and for use in graphic presentation constructed by computer techniques.

One result of this project has been a computer movie of the growth of Tulsa *(Brady et al. 1975)*. In it are depicted the physical annexation process, from the original townsite to its present configuration. In addition, the demographic features are illustrated on linear graphs showing some of the dynamic

Figure 2.—Consumption of electricity (in millions of kilowatt hours) in Tulsa, Oklahoma. Regression of log Y on X.

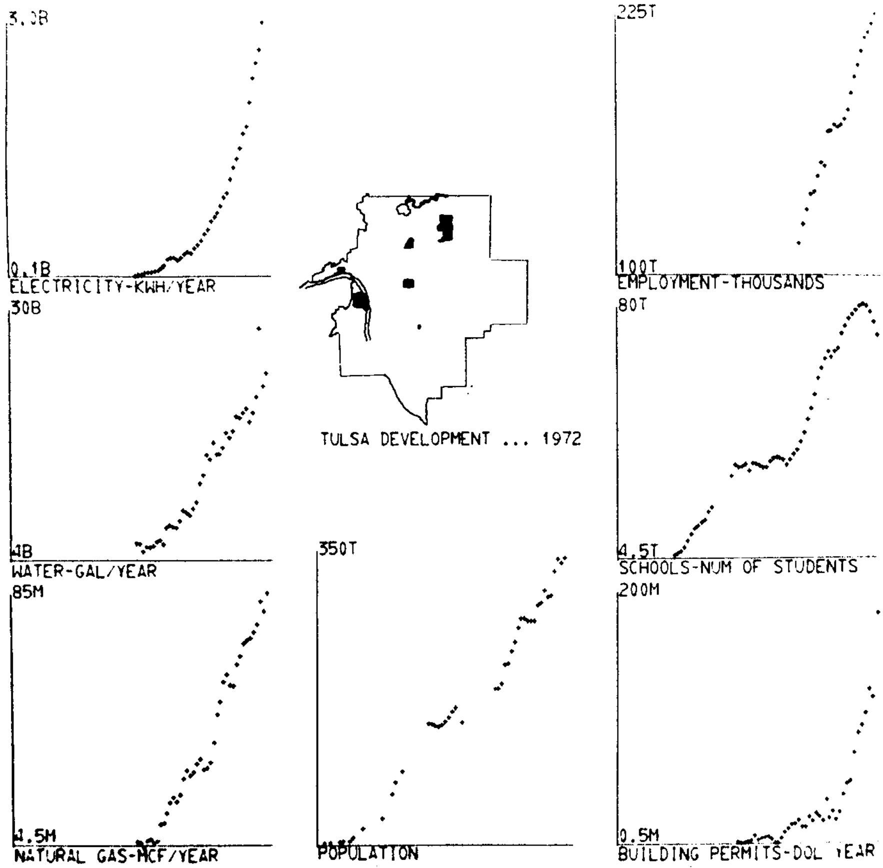


trends in this city: population growth, energy consumption, employment patterns, school enrollment, etc. (fig. 1 and 2). As a method for transferring techniques widely used in the scientific fields to that of planning for social needs, these computer graphic presentations have been found to be readily assimilable by the decision-maker as well as the ordinary citizen who has not had time to become algebraically oriented *(Eddy 1974)*.

FORECASTING DEMAND FROM PROPOSED DEVELOPMENTS

Evaluation of the impact of new developments in a community is another source of concern to urban decision-makers. Those agencies responsible for approving zoning and platting of proposed developments, in particular, find it necessary to make approvals for new developments without the assurance that public utilities and services such as water, sewers, and public schools will

Figure 3.—Computer movie of the growth of Tulsa, Oklahoma.



be available to adequately serve those developments after completion. The environmental impact is also many times left in question. The Proposed Development Sub-File is designed to provide a relatively accurate and rapid computerized system of predicting the needs and impacts of such developments *(Tulsa City-County Health Department 1972)*. The ability of this system of comparative computer programs to accumulate the anticipated impacts of all proposed developments (from the early stage of zoning change to completion) is of great advantage. The data system will be of benefit to government agencies by aiding planning for utility expansions and school facilities and in assessing housing trends and availability of services.

Those who invest in such developments may also benefit from this project, as it will be capable of serving as an early warning system in predicting probable future difficulties with existing facilities in the earliest stages of planning, and, therefore, modification or delay of development before the financial commitment has been further expanded. The system will provide reasonably accurate estimates of the effect of all proposed developments and existing developments on sewage-treatment plants, water plants, sources of water, public schools, solid-waste-disposal facilities, and environmental quality. A sample of the output expected for presentation to the decision-making bodies is presented here (fig. 4) as well as the predicted

Figure 4.—Impact of a proposed development on services and utilities.

WATER TREATMENT CAPACITY ASSESSMENT

COUNTY: TULSA

FACILITY: TULSA MUNICIPAL SYSTEM	AVE	PEAK
EXISTING TREATMENT CAPACITY	100 000 000	136 000 000
EXISTING DEMAND	64 400 000	117 000 000
REMAINING CAPACITY	35 600 000	19 000 000
PLATTED COMMITMENT	2 880 000	4 320 000
REMAINING CAPACITY	32 720 000	14 680 000
PRESENT ZONING COMMITMENT	8 640 000	12 960 000
REMAINING CAPACITY	24 080 000	1 720 000
PROPOSED ZONING DEMANDS		
Z 4701 CS	10 500	15 750
Z 4702 CS	35 000	52 500
Z 4706 CG OL	5 890	8 835
Z 4707 CS	56 000	84 000
Z 4712 CS OL RM-1 RD RS-3	425 200	637 800
TOTAL ZONING DEMAND	532 590	798 885
REMAINING CAPACITY	23 547 410	921 115
FUTURE DESIGN CAPACITY	110 000 000	145 000 000
YEAR: 1978		

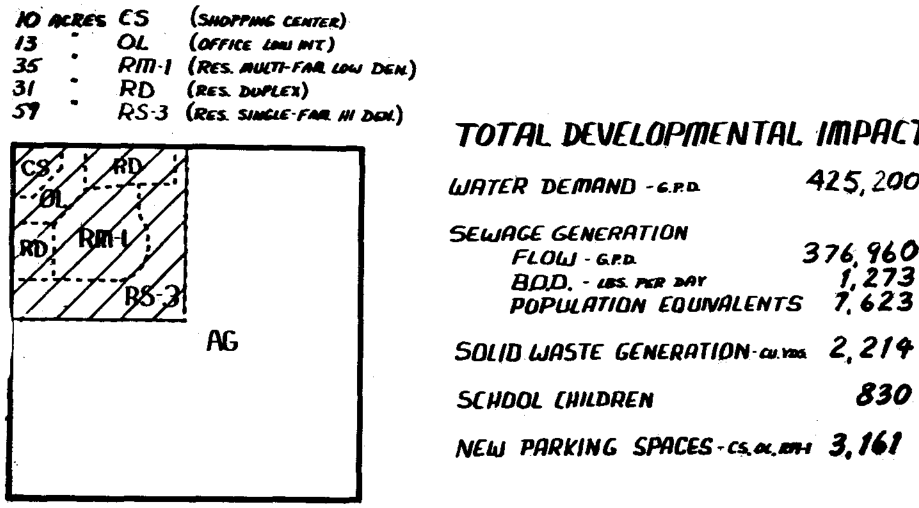
FACILITY: BROKEN ARROW PLANT

COUNTY: CREEK

WATER SOURCE ASSESSMENT

SOURCE: SPAVINAW	AVE	PEAK
RELIABLE YEILD	65 000 000	65 000 000
EXISTING DEMAND	64 400 000	117 000 000
REMAINING YEILD	600 000	-52 000 000
PLATTED COMMITMENT	2 880 000	4 320 000
OVERLOAD	-2 280 000	-47 680 000
PRESENT ZONING COMMITMENT	8 640 000	12 960 000
OVERLOAD	-10 920 000	-60 640 000
PROPOSED ZONING DEMANDS		
Z 4701 CS	10 500	15 750
Z 4702 CS	35 000	52 500
Z 4706 CG OL	5 890	8 835
Z 4707 CS	56 000	84 000
Z 4712 CS OL RM-1 RD RS-3	425 200	637 800
TOTAL ZONING DEMAND	532 590	798 885
OVERLOAD	-11 452 590	-61 438 800

Figure 5.—Sample output of proposed development system, showing assessment of demands on water treatment and water source.



impact of a hypothetical development as it would be assessed by this system (fig. 5).

AIR-POLLUTION MODELS AND COMPUTER MOVIES

Several existing air-pollution models have been adapted to the air-quality conditions in the Tulsa area. An illustrative sample of the Climatological Dispersion Model *(Busse and Zimmerman 1973)* is presented here. An annual average of ground-level concentrations of pollutants from both point and area sources is obtained by using this model. By using the original program, receptor points can be located to pinpoint concentrations of two pollutants at a time.

In addition, program modifications have made it possible to map concentrations of pollutants at locations arranged in a grid of specified size, rather than individual receptor sites, as reported by Normand *(1975)*. The unit area of 1 square mile was chosen to conform to the grid pattern of the major streets of Tulsa. The concentration estimate is made for receptors located at the center of these square-mile areas. A cross-section of the grid along a north-south column is shown here (fig. 6), for the effluent SO_2. This display of pollution concentration is an aid to visual perception of the dispersion of air pollution over a city-wide area. This method can be used by urban planners in assessing the impact of new industrial location on an annual basis.

Another model, which takes into account the differentiations in terrain of an urban area, as well as time and space variations in the wind field and stability of atmospheric conditions, is the Diffusion Wind Atmospheric Dispersion Model developed by Shannon *(1974)*. This is a four-dimensional model (X, Y, Z, T). The grid is vertically divided into eight layers, with a horizontal grid-mesh size of 1 square mile. Wind stability and effluents vary in space and time (fig. 7 and 8). A three-dimensional computer movie has been made *(Shannon 1974)* of the output of this model, showing a cloud of pollution moving across an urban area. The pollutants and stability are varied at 5-minute intervals.

This model permits the examination of the frequency distribution of various pollutants on different space-time scales.

Figure 6.—Cross-section of grid showing concentrations of SO_2 predicted by climatological dispersion model.

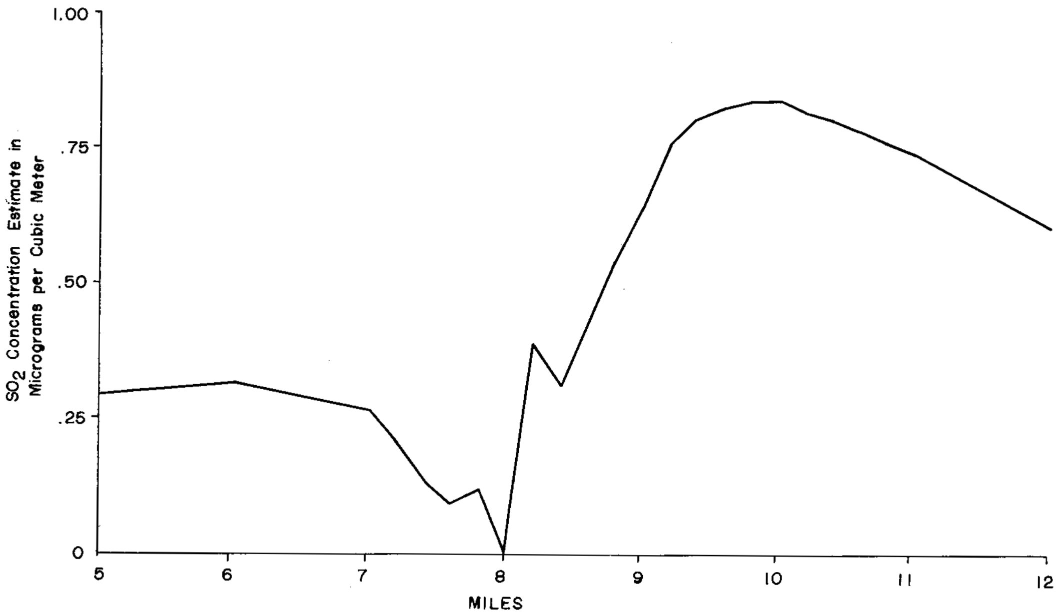
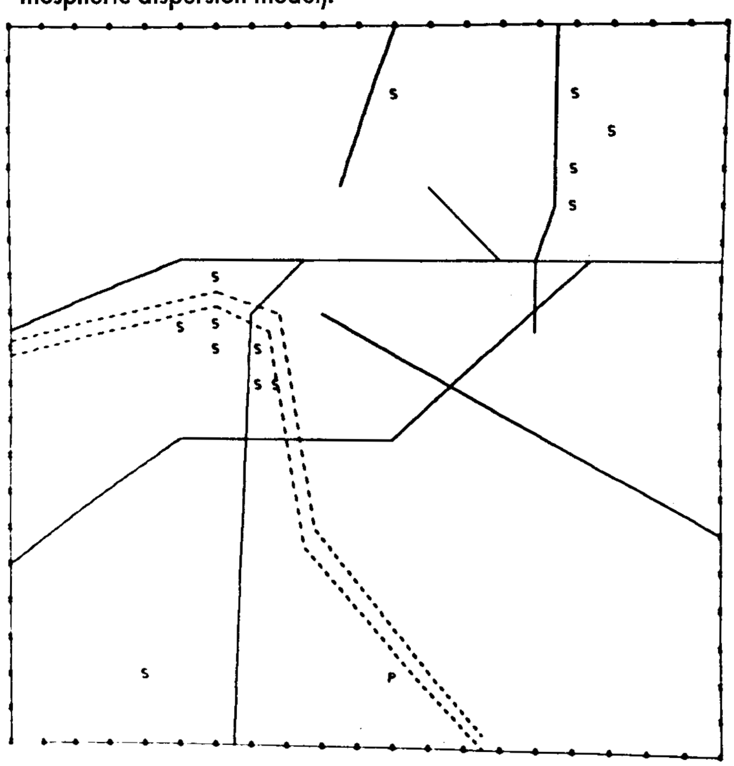
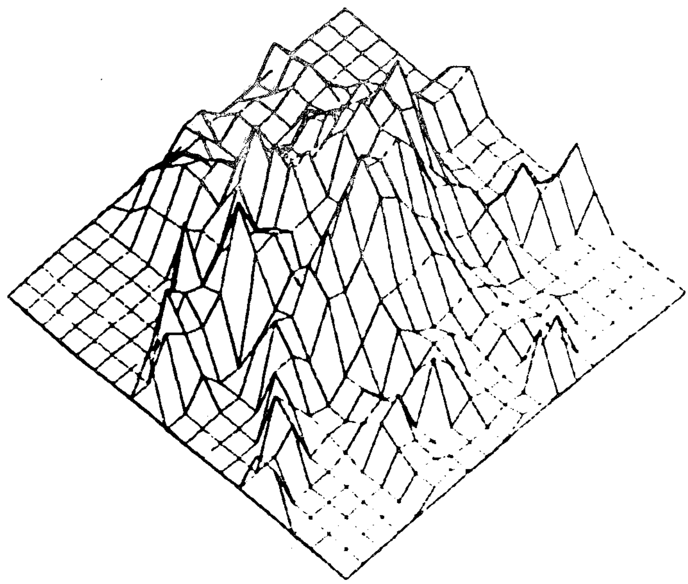


Figure 7.—Tulsa industrial point sources, future electrical generating plant site, freeways (output from diffusion wind atmospheric dispersion model).



TULSA INDUSTRIAL POINT SOURCES (S), FUTURE ELECTRICAL GENERATING PLANT SITE (P), FREEWAYS (SOLID LINES). ARKANSAS RIVER (DASHED LINES) GRID INTERVAL ONE MILE. TOP IS NORTH

Figure 8.—Hydrocarbon emissions from current traffic (Kg./sq. mi./day).



LOWER CORNER IS SOUTHWEST CORNER

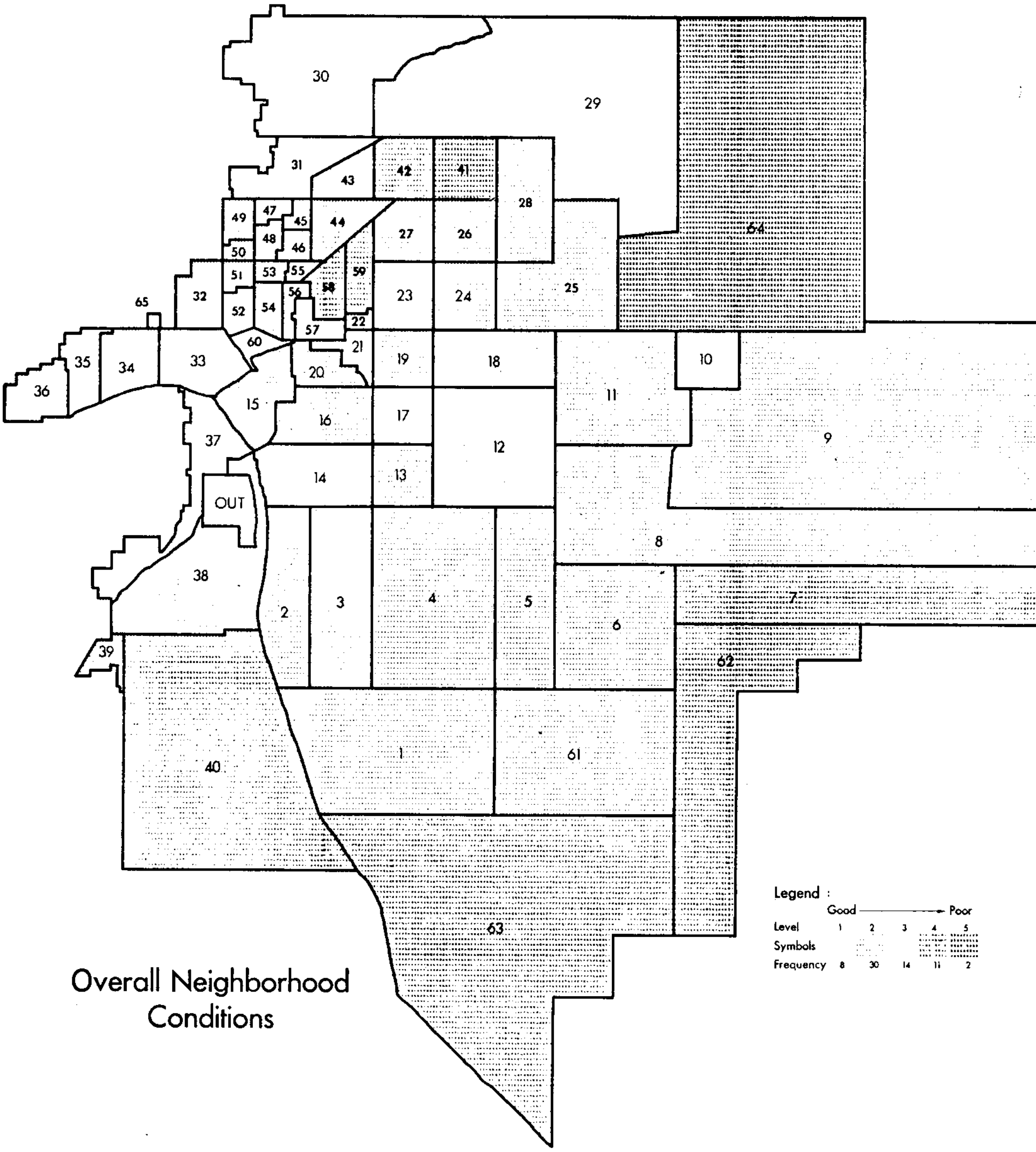
Optimal placement of monitoring sensors, as well as prediction of the impact of new industrial sites are two of the possible applications of this model for the planner of the metropolitan environment. Computer-produced movies of air-pollution patterns have proved very valuable for transferring large amounts of technical information in an easily assimilable format to nontechnical decision-makers in a short time.

ENVIRONMENTAL DEFICIENCIES VERSUS DEMOGRAPHIC CHARACTERISTICS OF A CITY

Evaluation of physical environmental deficiencies in relation to the characteristics of the population was the subject of another report. Data collected by the Tulsa City-County Health Department was selected for the study. Several computer programs that employed statistical techniques were used. Multiple linear regression and stepwise regression were used, and the relationships found are reported by Normand *(1974)*.

In a more extensive study by the Tulsa City-County Health Department, the whole area of Tulsa was surveyed, and many other variables were considered, employing the Neighborhood Environmental Evaluation Decision System (NEEDS), developed by the Bureau of Community Environmental Management of the Health Services and Mental Health Administration, U. S. Public Health Service. The statistical methods used in this survey were correlation analysis, factor analysis, cluster analysis, and regression analysis. An evaluation was made of complex combinations of interrelated conditions occuring in the living environment of specific areas of the community. Fig. 9 shows the ranking of overall neighborhood conditions, as one of the many variables analyzed. The net result of this study was to produce a statistically logical set of planning districts, each one of which

Figure 9.—Overall neighborhood conditions from NEEDS study in Tulsa, Oklahoma.



contained homogeneous attributes that distinguish it from its neighbors.

SUMMARY

Experts employed to solve the problems facing the metropolitan areas today are faced with dilemmas. One is the language barrier between different disciplines. The transfer of information and technology is the first obstacle to overcome. Some techniques of data assimilation that can be used to overcome the communication problem have been presented in this paper. An attempt has been made to show some techniques employed now by the sciences, which could be used to provide accurate and instantaneous presentations of consequences of past and possible future actions by the administrators of metropolitan areas. The rapid pace at which change occurs is highly visible in large urban concentrations. The technology is available to show alternative methods of resource allocation to accommodate changes, and it is hoped that this effort will provide encouragement to the planners of metropolitan environment to make use of such techniques.

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