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community crime prevention

The Display of Geographic Information in Crime Analysis

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THE DISPLAY OF GEOGRAPHIC INFORMATION IN CRIME ANALYSIS

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INTRODUCTION

In many facets of planning and research, the speed at which information can be accessed and processed is critical. But even timely information must be presented in a form which facilitates rapid analysis and interpretation in order to be useful in many criminal justice policy and tactical law enforcement situations. By utilizing computers, planners and researchers can achieve the speed necessary to access and process the enormous amounts of raw information which often must be fed into their decision making; and by utilizing computer generated graphics as one mode of information presentation, the amount of time which must be devoted to interpretation of analytic results may be drastically reduced. Tremendous amounts of information can be represented in graphic output. Because of this, computer generated graphics can serve an important role in the communication of analytic results. Maps are perhaps the most lucid form of graphic display in situations where the nature of area-wide distributions are of interest. Information which is clearly conveyed will certainly prove to be of more value to policy makers than that which is not. Accordingly, the educational value of computer-generated maps in addition to the analytical value should not be overlooked.

Our concern here is with the presentation of geographic information, at an appropriate level of analysis, with an appropriate level of precision and accuracy.

One kind of crime data often analyzed in a geographic context is crime event information. This kind of data is available from a variety of official sources as both raw and summarized crime incident reports. While the scale of analysis chosen by a researcher should be constrained by the questions asked, the method chosen is more often the result of the so-called "law of available data." As Brantingham et al note (1), most sociological research utilizing crime rate data is conducted at the census tract level because a great quantity of tract level SES census data is easily available. Many tactical decisions, such as those relating to resource or manpower allocation, are made based on precinct or other "grid" level information because that unit of analysis is actually used for tactical deployment, or simply because that is how information is routinely summarized by the agencies involved (2). While pre-defined summary area data is often not appropriate for many purposes, its limitations can be overcome by utilizing address level information and research-specific aggregations.

What follows is a description of display techniques for research, tactical deployment, or policy analysis at several levels of aggregation:

1)Pre-defined summary areas, e.g. tract, precinct, or grid
2)Address level, e.g. individual incident sites
3)Analysis-specific aggregations from address level information

DISPLAY AND ANALYSIS OF AREA SUMMARY INFORMATION

The analysis of crime event data is often accomplished by comparing differences in crime rates across subareas of some jurisdiction. Where the researcher can hypothesize that behavioral differences are a function of some manipulable factor, this kind of analysis can be used directly in the policy-making process. A means of helping the policy maker visually discriminate between subareas can greatly facilitate this process.

MAPPING TECHNIQUES

One means of doing area discrimination analysis involves using what are called "choropleth" mapping techniques. Choropleth maps are shaded maps of an area, which discriminate between subareas on the basis of shadings which correspond with the crime rate being mapped.

However, the degree to which a choropleth map distinguishes between subareas depends upon the type of categorization procedure imposed upon the data by the researcher. Choropleth techniques usually use no more than five or ten distinct categories into which the entire range of observed values must be mapped. This limitation stems from the fact that as a larger number of shadings are used in a single map, visual fidelity quickly gives way to confusion. Human limitations in the ability to discriminate between shadings are quite pronounced. Accordingly, where the number of unique values being represented on a choropleth map exceed the number of categories being used, as is usually the case, information is lost in the categorization process.

Two categorization procedures in common use in choropleth mapping are equal membership and equal size interval. The equal membership procedure puts an equal number of subareas into each shading level category. This results in a ranking of subareas into a fixed number of categories. Unfortunately, very small differences in the values of two subareas may be large enough to place them in separate categories, often resulting in a rather arbitrary discrimination between similar subareas. The equal membership categorization procedure involves a two step loss of information from the data being mapped: 1) interval information about the distance between rankings is disregarded when assigning cases to categories, and 2) as a categorization procedure, even the ordinal information about the observations within each category is lost. This loss of information can be seen in Figure one, an equal membership choropleth representation of commercial robbery frequency in Minneapolis (3). Using five equal membership categories, about 25 tracts must be assigned to each category.

[INSERT FIGURE ONE]

An alternative procedure, equal size interval categorization, (which, as its name suggests, sets up categories of equal interval size), solves the problem of somewhat arbitrary classification introduced by the equal membership procedure, but runs the risk of a different kind of loss of precision. The presence of extreme values in the data set can generate a map with data in only a very few categories. Even though it retains information about the interval size between categories, under certain circumstances, the equal size interval procedure can introduce a greater loss of information than the equal membership procedure. This loss of information is demonstrated in the equal interval representation of commercial robbery frequency in Figure two. Due to the presence of a small number of tracts with very high frequencies, virtually all of the tracts are categorized into the lowest or highest categories.

FIGURE 1

COMMERCIAL ROBBERY FREQUENCY
(EQUAL MEMBERSHIP)

SOURCE: Minneapolis police offense report data, July 1, 1974, through June 30, 1975.

[INSERT FIGURE TWO]

As noted above, choropleth mapping techniques are limited by the inability of persons to discriminate between more than a very few levels of shading, and by the potentially misleading loss of information caused by forcing a wide range of unique values into a much smaller number categories.

These difficulties can be eliminated by using an alternative mapping procedure which neither categorizes nor depends on shading in order to differentiate between levels of the variable being mapped. One such technique involves representing subareas and their associated values as a three-dimensional object (see Figure three). The object itself can be mathematically generated and visually displayed through the use of computer graphics technology.

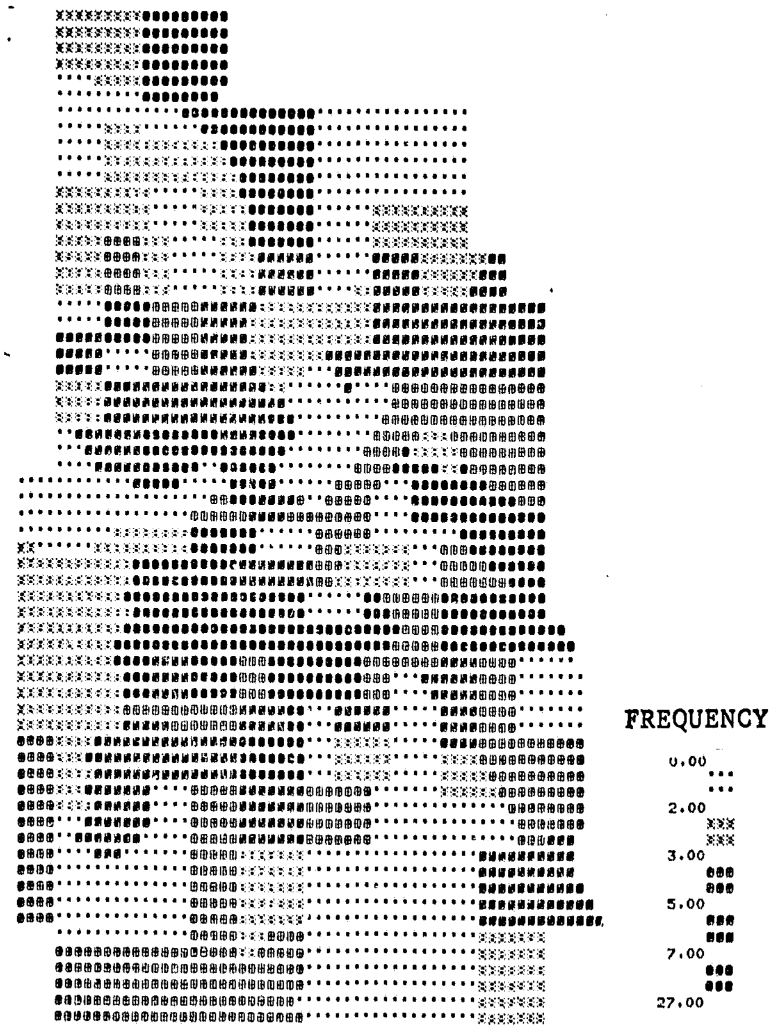
[INSERT FIGURE THREE]

The use of three-dimensional representations can provide a net gain of information for use by the researcher or policy maker; true variations in the levels of the variable being mapped are exactly represented. When all of the subareas being mapped are viewed as a single three dimensional object, subtle variations between subareas, and patterns among subareas become clearly apparent. Differences in analytic perspective can be easily compared through the use of three-dimensional mapping techniques. Three-dimensional representations of commercial robbery in Minneapolis (Figure four) give quite different views of the problem when mapped from the perspective of frequency (over one year) and risk (proportion of commercial units robbed over one year). Note that the downtown business district is

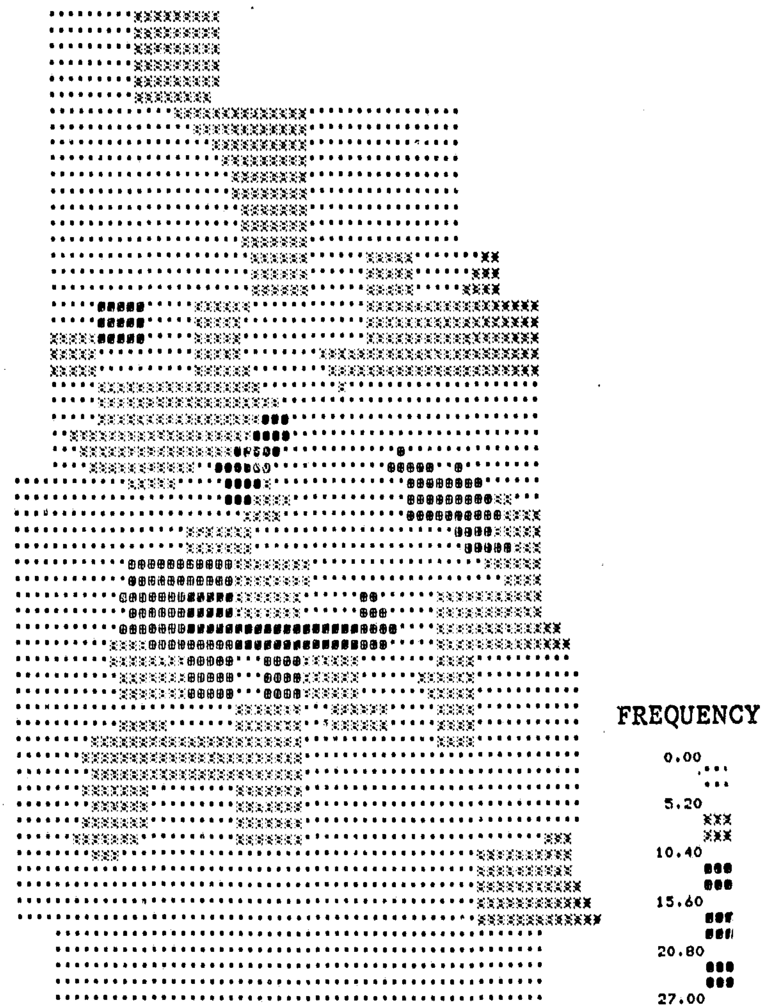
FIGURE 2

CONTRASTING CHOROPLETH CLASSIFICATION PROCEDURES

COMMERCIAL ROBBERY FREQUENCY
(EQUAL MEMBERSHIP)



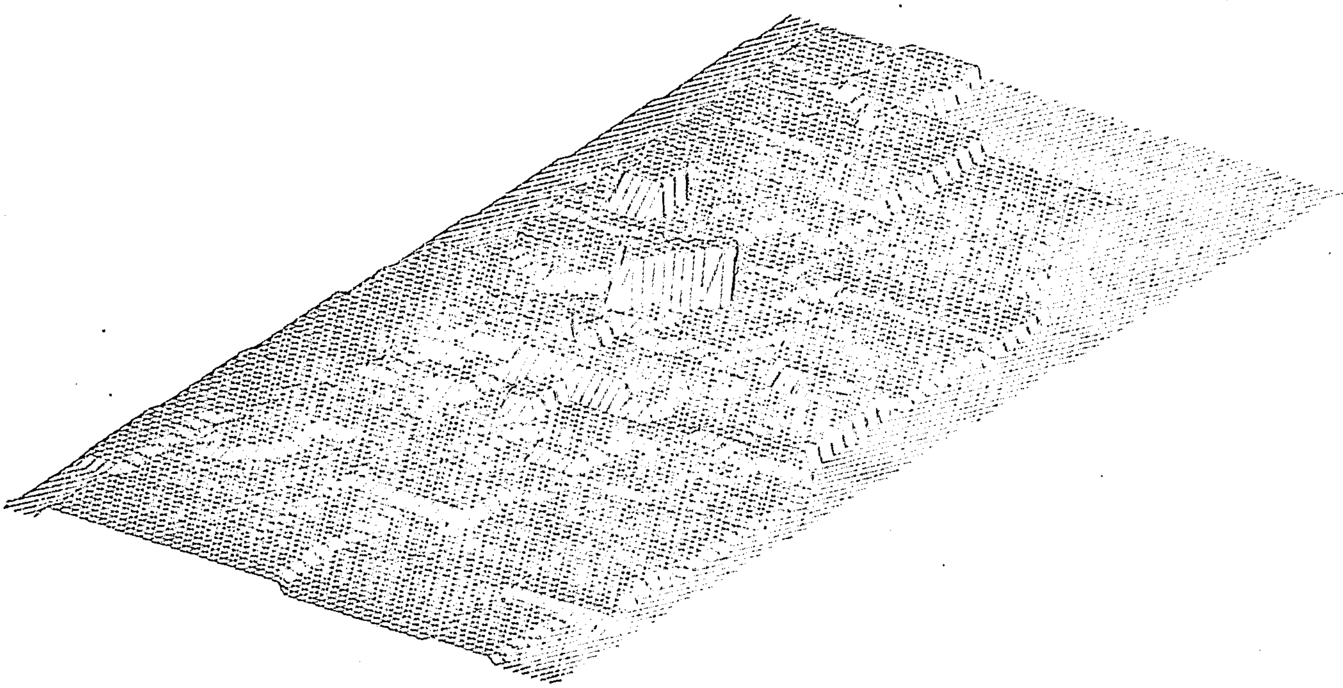
COMMERCIAL ROBBERY FREQUENCY
(EQUAL INTERVAL)



SOURCE: Minneapolis police offense report data, July 1, 1974, through June 30, 1975.

FIGURE 3

THREE DIMENSIONAL REPRESENTATION OF COMMERCIAL ROBBERY FREQUENCY BY TRACT



SOURCE: Minneapolis police offense report data, July 1, 1974, through June 30, 1975.

the highest "hill" in the frequency representation and the lowest "valley" in the risk representation. Although Figure four does not clearly demark particular city features, it is an easy task to display features such as tracts, or rivers found on other maps. Additionally, the researcher viewing such a representation is of necessity famliar with the location of city features long before this representation of data is generated.

[INSERT FIGURE FOUR]

DISPLAY AND ANALYSIS OF ADDRESS LEVEL INFORMATION

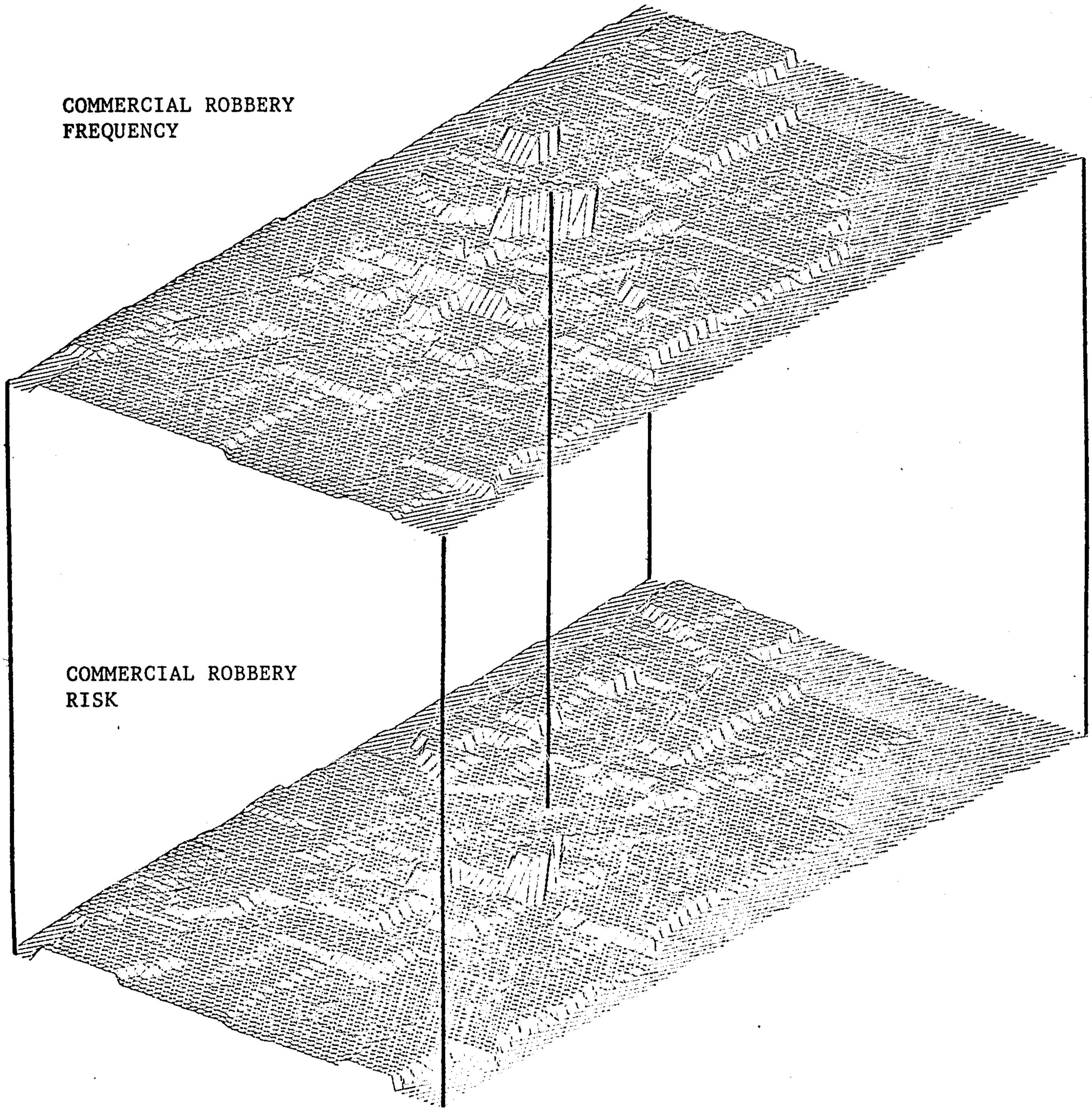
The most basic element of crime related geographic information is the individual address, usually that of an offense site. When crime related information is aggregated to any geographic area, it is this address level information which is summarized. In the process of summarization, information about individual addresses is lost (see Figure five). And yet, address level information is necessary for many purposes. Analysis of micro-level phenomena, such as crime around specified nodes like bars, adult entertainment facilities, or even police precinct stations, can only be done with address level information. The identification of "hot spots" or commercial strips with special crime problems also necessitates the use of address level information.

[INSERT FIGURE FIVE]

Resource allocation strategies, such as physical redesign or intensive manpower allocation, become more practical and potentially

FIGURE 4

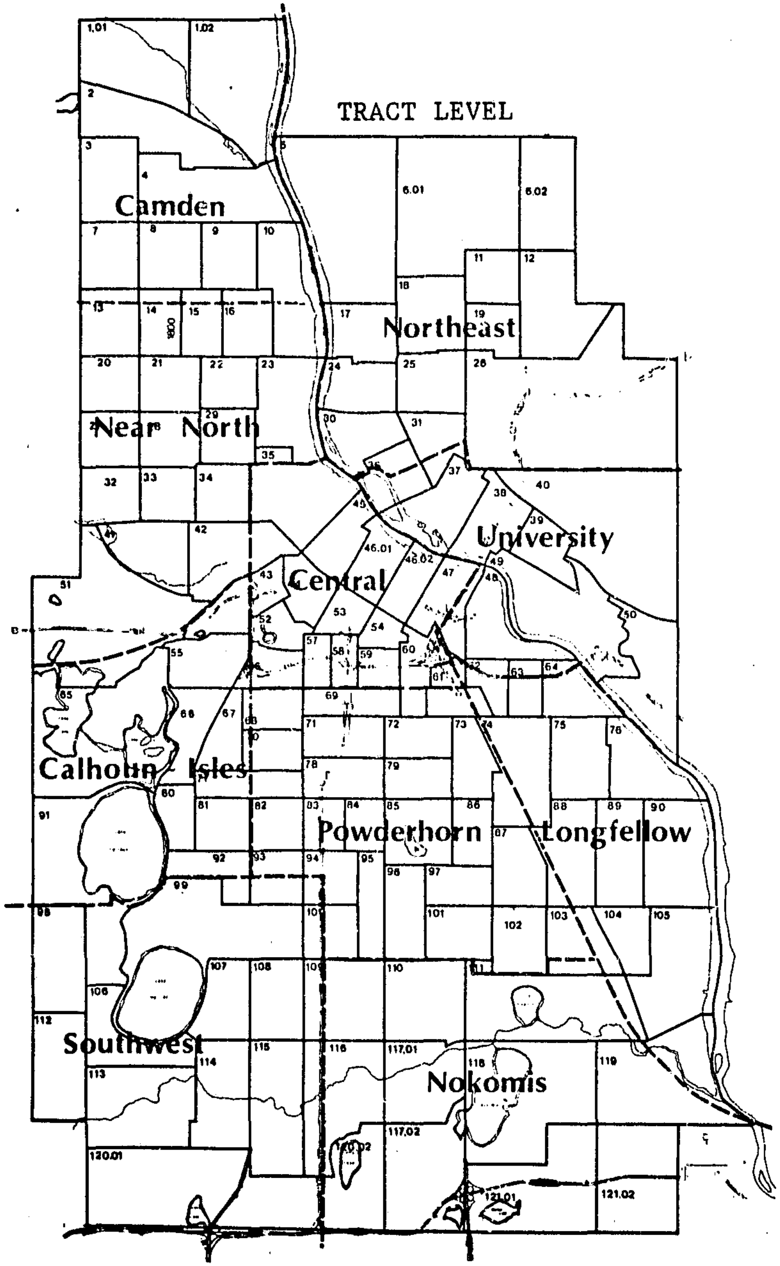
THREE DIMENSIONAL COMPARISONS OF COMMERCIAL ROBBERY FREQUENCY AND COMMERCIAL ROBBERY RISK

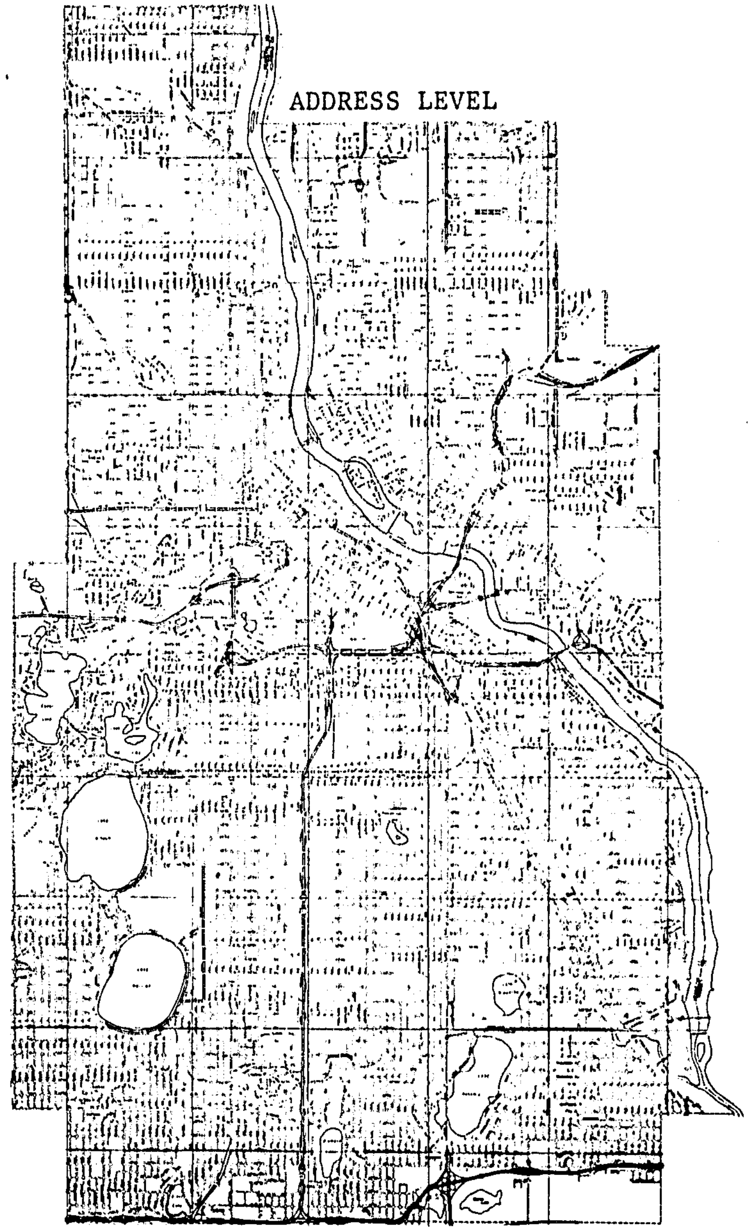


SOURCE: Minneapolis police offense report data, July 1, 1974, through June 30, 1975.

FIGURE 5

CONTRASTING LEVELS OF ANALYSIS IN MINNEAPOLIS





more cost effective when small but severe trouble spots can be identified. The process of identifying these trouble spots can best be accomplished with address level information.

Our analysis of stranger to stranger assault in Minneapolis on the tract level identified the entire downtown area a trouble spot, while, as can be seen in Figure six, the more detailed address level analysis pin-pointed Hennepin avenue, or more specifically, a row of adult entertainment establishments, as the site of nearly all of the offenses in the area.

[INSERT FIGURE SIX]

THE DISPLAY OF ANALYSIS-SPECIFIC AGGREGATIONS

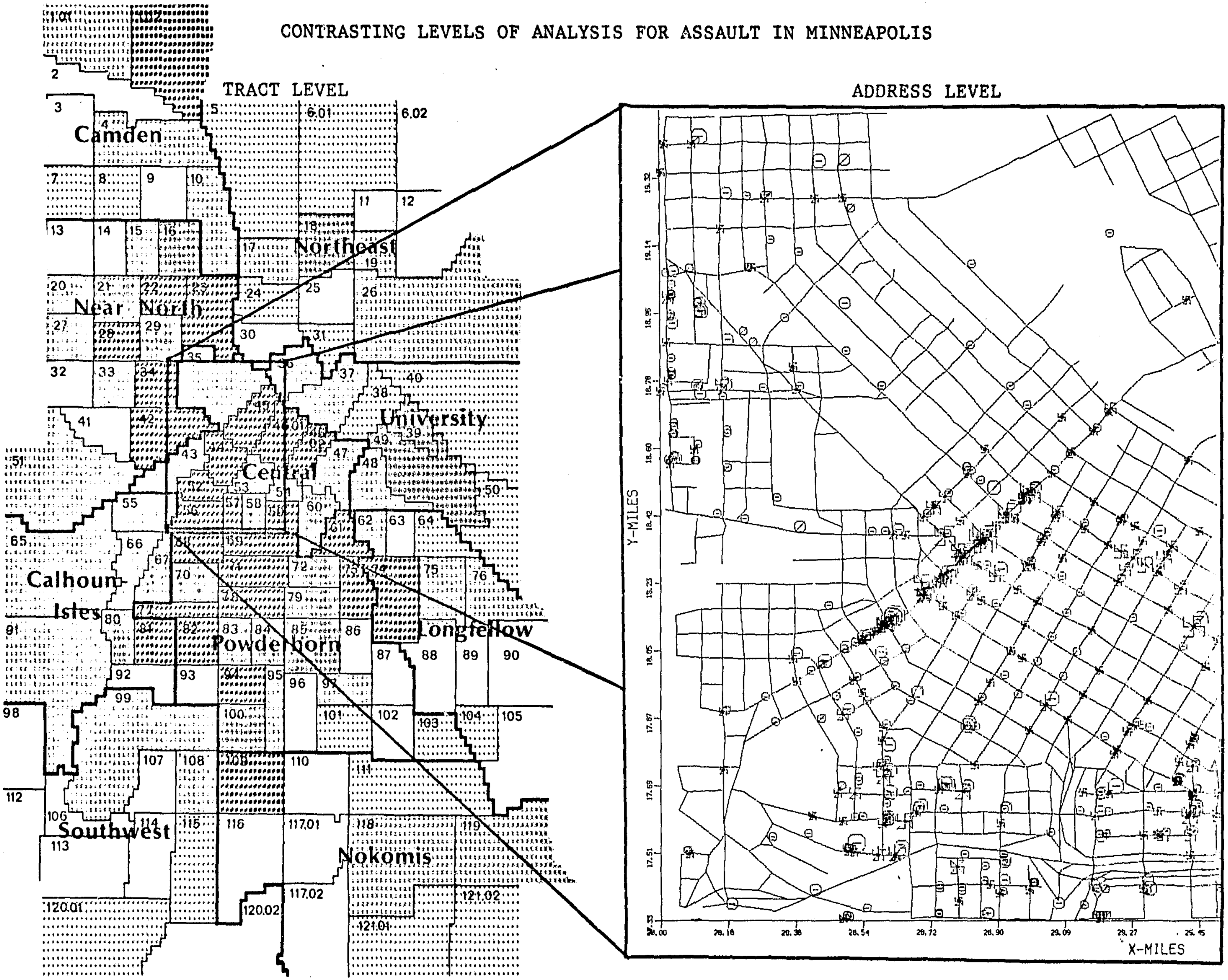
Address level information need not be applied exclusively at micro-analytic level. Analysis specific aggregations are directly recoverable as needed from address level data. For instance, when asked by the City Planning Agency to determine if crime rates near police precinct stations in Minneapolis are lower than in other areas of the city, our research design called for computing the crime rate (in crimes per square mile) in circular bands of increasing radii from each precinct station, in order to construct distance-decay curves. A distance-decay curve displays the change in crime density as one approaches the immediate vicinity of some point of interest, in this case, a police precinct station (see Figure seven).

[INSERT FIGURE SEVEN]

Using address level data, spatial analyses of any level of

FIGURE 6

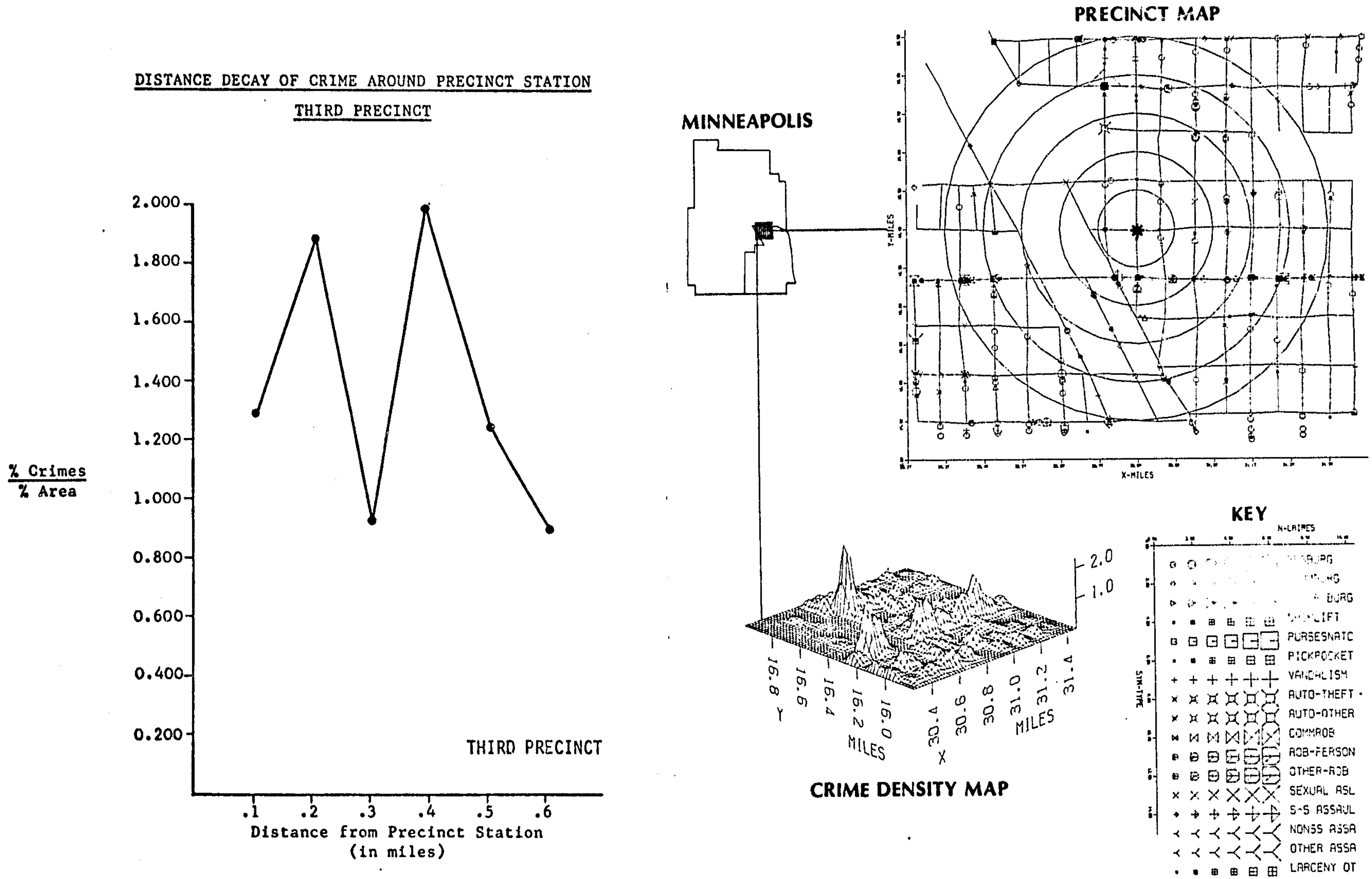
CONTRASTING LEVELS OF ANALYSIS FOR ASSAULT IN MINNEAPOLIS



SOURCE: Minneapolis police offense report data, July 1, 1974, through June 30, 1975.

FIGURE 7

A NODE ANALYSIS OF CRIME AROUND PRECINCT STATION THREE IN MINNEAPOLIS



SOURCE: Minneapolis police offense report data, July 1, 1974, through June 30, 1975.

sophistication can be applied to an entire city, resulting in a view of the city which reflects global behaviors which may be lost through aggregate analyses. Detailed identification of barriers to crime, streets or facilities conducive to crime, or even changes in levels of seriousness of crime can be generated for an entire city from address level data. Isopleth mapping techniques can be used to empirically aggregate data into irregularly shaped contour regions of similar values on a variable of interest. These regions can be represented in a variety of ways, such as contour lines, shaded contour bands, or as a three-dimensional object. For example, note in Figure eight the differing levels of stranger to stranger assault seriousness in Minneapolis (as measured by the Sellin-Wolfgang index) uncovered by use of this technique.

[INSERT FIGURE EIGHT]

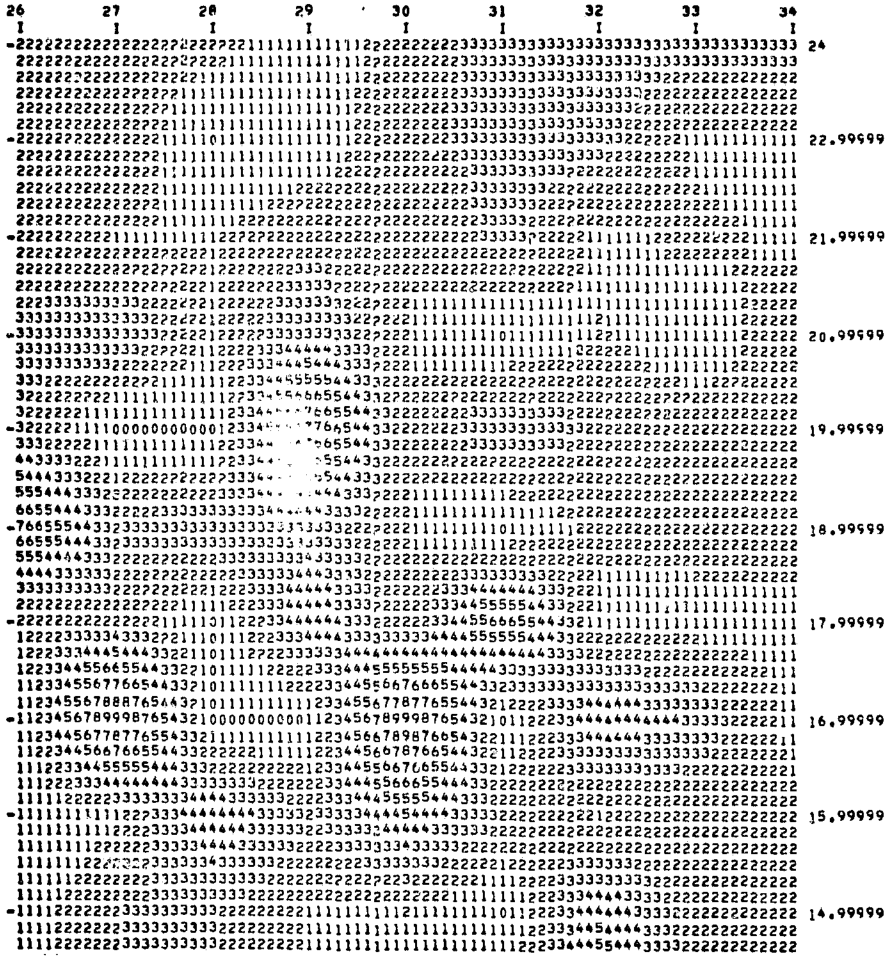
CONCLUSION

The use of computer generated graphics as one form of presentation for geographically related crime information provides speed and versatility of analysis to the researcher and policy maker. A wide range of techniques exist for the analysis and display of both aggregated and address level information. Computer generated mapping techniques are useful not only in analysis, but in the presentation of analytical results as well. For many purposes, they can convey enormous quantities of information with clarity which is unsurpassed by other forms of information display. Some major applications of these techniques for criminal justice policy and

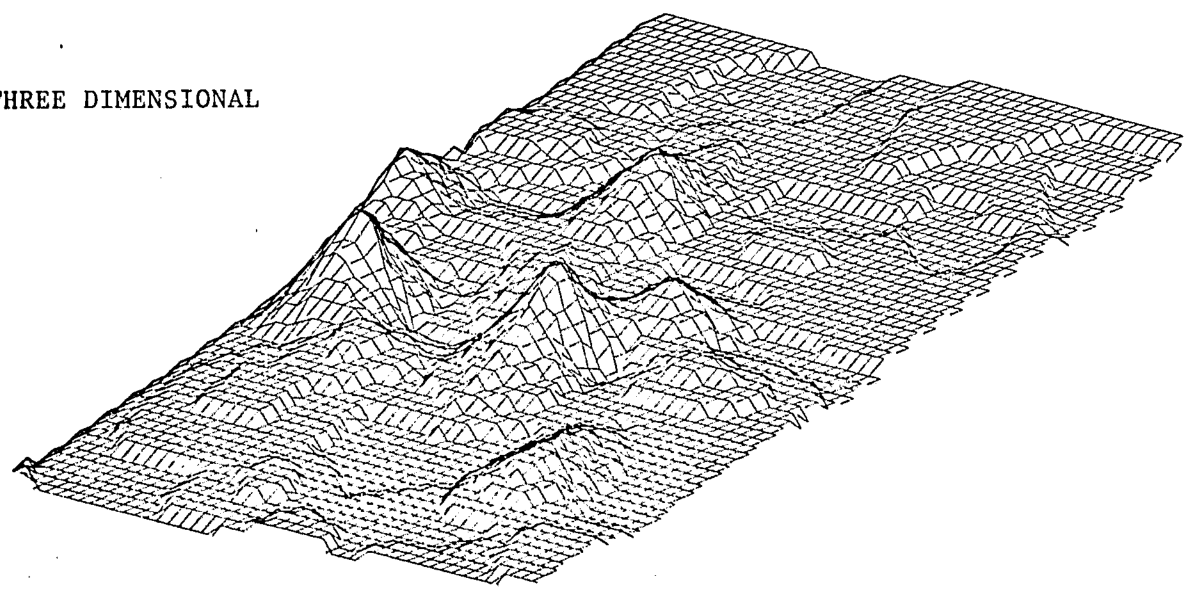
FIGURE 8

ISOPLETH MAPS OF ASSAULT SERIOUSNESS FOR THE CITY OF MINNEAPOLIS

TWO DIMENSIONAL



THREE DIMENSIONAL



SOURCE: Minneapolis police offense report data, July 1, 1974, through June 30, 1975.

tactical deployment situations have been demonstrated in this paper.

FOOTNOTES

(1) Paul J. Brantingham, Delmar A, Dyreson, Patrcia L. Brantingham, "Crime Seen Through a Cone of Resolution," American Behavioral Scientist, 20 (1976)

(2) Of course, statements made from empirical analysis of such aggregated data about the behavior of individuals may suffer from the well known ecological fallacy, that is, unwarrented assertions about individual behavior made from purely aggregated data.

(3) All computer generated graphics in this report were produced by ATHENA, a comprehensive package for planning, resource allocation, and analysis, now undergoing preliminary implementation by the authors at the Minnesota Crime Control Planning Board.

END