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Document Title: Summary of Mapping Violence and High Frequency Calls for Police Service: The Charlotte, North Carolina Example

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Document Number: 171646

Date Received: 1996

Award Number: 94-IJ-CX-0045

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94-IJ-CX-0045

A Summary

of

Mapping Violence and High Frequency Calls For Police Service:

The Charlotte, North Carolina Example

by

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Sponsored
by

The National Institute of Justice
Grantor Reference # 94-IJ-CX-0045

May 27, 1997

This report was supported by Grant Reference # 94-IJ-CX-0045 from The National Institute of Justice to Southern Illinois University at Carbondale. Findings and conclusions of the research reported here are those of the author and do not necessarily reflect the official position or policies of the U.S. Department of Justice.

Findings and conclusions of the research reported here are those of the author and do not necessarily reflect the official position or policies of the Charlotte-Mecklenberg Police Department.

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INTRODUCTION

The tremendous advances in computing have been responsible for increasing the interest and use of automated mapping programs and geographic information systems (GIS) by law enforcement agencies. Recently, Rich (1995) presented case studies illustrating how this technology is being used in selected police departments. Nevertheless, a critical assumption defining this project is that the benefits accrued from using this technology for analyzing policy, directing operations, and augmenting managerial decision-making will be significantly less than optimal because the diffusion and adoption of this technology has been so rapid that mapping, spatial analysis, and geographic information systems became separated from the knowledge bases defining them. To put it more succinctly: many people do not know how to make maps, use geographic information systems, and conduct spatial analyses because in the rush to get going with this technology many unwary users have relied upon the software documentation for their conceptions of map making, GIS, and spatial analysis and not the extensive literature in cartography and geography - the disciplines responsible for spawning mapping, spatial analysis, and geographic information systems.

The simple message to be conveyed by this project is that mapping is not a unitary concept. There are different types of maps for describing, depicting, and analyzing different phenomena. The purpose of this project is to illustrate how a specific type of GIS produces a specific type of map which enhances the ability for measuring and seeing the change of calls for service through time.

Data and Research Site

This project uses computer aided dispatch records from the Charlotte, North Carolina, Police Department for the time period 1984-1993. This data set, consisting of more than three million calls for service, has two features which are very helpful for this research. First, duplicate calls and multiple calls reporting the same event are eliminated, thus enhancing the reliability that an incident or call is truly unique and only being counted once. Second, when it is appropriate each call is classified according to its corresponding Uniform Crime Report (UCR) classification. Therefore, it is possible to sort out specific types of violent offenses from service, traffic and other order maintenance calls for service.

This project examines the spatial distributions of specific violent crimes and high frequency calls for police service through time. However, because of space limitations for this report the discussion will focus on one type of call for service that is frequent, controversial, and potentially violent - domestic disputes.¹

Exhibit 1.0 depicts the volume of domestic disputes relative to the total number of calls for service received from 1984-1993. Essentially, domestic dispute calls constitute between 7 and 9 percent of all calls for service. Generally, calls for service and domestic disputes have been increasing during the study period. While there are noticeable year-to-year fluctuations it is beyond the scope of this report to discuss significant causal mechanisms and policy interventions accounting for the changes.

¹A call is labeled a domestic dispute after a police telephone operator, according to policy, receives some vital and basic information about the nature of the complaint from the caller.

Exhibit 1.0 about here

Raster Based Geographic Information System

This project employs the *IDRISI* raster based geographic information system.² A GIS is any manual or computer based set of procedures used to store and manipulate geographically referenced data (Aronoff, 1989). Computer based GIS represents digital data in either vector or raster formats. In the former, geographic features or boundaries are represented by a series of coordinate points and line referenced by some form of grid system(i.e., x,y Cartesian coordinates, latitude-longitude). In the latter format the geographic surface to be mapped is divided into a row column matrix or grid lattice with data recorded for every cell. Therefore, identifying a feature or boundary involves allocating a particular value or color shading to the cells containing the feature or boundary (Eastman, 1992: 22). Both formats have their advantages and limitations. The raster format is very data intensive and presents storage problems, while the vector format is very good for data base management, storage, and producing attractive maps. The main advantage of the raster format is that it has much more analytical power than the vector system (Eastman, 1992: 22). A hypothetical example may clarify the differences between the two formats.

Suppose one is interested in examining the changes in crime across neighborhoods between two time periods. Normally, with either format, maps would be made of time periods 1

²*IDRISI* is created and supported by the Clark Labs for Cartographic Technology and Geographic Analysis, Clark University, Worcester, MA

and 2 allowing visual comparisons. However, constructing a third map showing the changes between the two time periods involves different steps for each format. The vector format would require manipulation of a data base management system whereby the number of crimes for each neighborhood during time period 1 is subtracted from the number recorded during time period 2. The difference values are then subjected to a mapping program and a third map is produced. In the raster format, because the row and column matrices are identical for both time periods ascertaining the difference is simply a matter of subtracting one map from the other to produce a third map showing the differences. Accessing and manipulating a data base management system is not necessary, because the maps are being manipulated and analyzed not a data base.

Isarithms, Interpolation, and Isopleths

The methodology employed for this project emanates from isarithmic mapping. This type of mapping is employed for creating and visualizing three dimensional surfaces. Normally, isarithmic mapping is used in terrain analysis and is essentially concerned with mapping out lines of equal value (i.e., contour lines or elevations of equal magnitude). However, one form of isarithmic mapping is a technique which estimates the values for geographic or areal units from point coordinates representing the centers of the units (See, Robinson, et al., 1995: 509-515). This procedure is known as interpolation.

There are several different interpolation algorithms which are used to predict the values of a phenomenon among control points of a surface (See, Robinson, et al., 1995: 509-515). This project uses an interpolation algorithm in the *IDRISI* software known as inverse squared-distance weighting. Basically, the control points representing the centers of geographic units are submitted

to an algorithm whereby the values for locations among the control points are estimated based on the inverse square of the distance among the control points and the value of the phenomenon at the points (See, Clarke, 1995: 250-251)

Each call for service received by the police communications center is located by its street block address and response area. The latter is a geographic unit composed of several block groups and serves as the basic unit for allocating patrol resources. While the response areas do not violate census tract boundaries they are not congruent with census block-groups. There are approximately 344 census-block groups within or intersecting the city limits while there are 537 response areas. Exhibit 2.0 shows the city limits of Charlotte, the polygons constituting the 1990 Census Block Groups, and response area centroids.

Exhibit 2.0 about here

The 537 centroids or control points are placed on a 300 x 300 grid. The interpolation algorithm uses a search procedure of the nearest six centroids from a specific centroid for calculating the value of the surface, or in this case the number of domestic disputes, at, between, and among the centroids.

Different Ways of Mapping and Seeing Change

Comparing Maps of Different Time Periods

An elementary way to examine change of a phenomenon through time is simply to construct maps of the phenomenon for the time periods of interest. The maps in Exhibit 3.0 are the results of the interpolation procedure and depicts the spatial distribution of the square root of

the frequency of domestic disputes for each response area for 1984 and 1993. The square root is used in order to facilitate comparisons between the years.

Three essential features are included in Exhibit 3.0 in order to simplify map interpretation. The first is a compass rose informing the viewer of the orientation of the map (i.e., which way is North). The second is a bar scale which gives the viewer an idea of the areal extent of the features being mapped (See, Robinson, et al, 1995, and M. Monmonier, 1993). The third important feature is the legend or key which helps the viewer interpret symbols, lines, patterns, and statistical data on the map. The color palette serving as the legend in Exhibit 3.0 has 17 different colors or levels. The number under each box represents the beginning square root for the specific interval. For example, the interval labeled 9 means that the beginning value is 9 and the last is 9.999. The palette for the maps and legend was selected for two reasons: first, among the several palettes tested this one was better for visualizing change; and second, using green to represent the higher frequencies of domestic disputes reflects an agricultural or botanical analogy. In other words, green represents response areas where the conditions for the growth of domestic disputes are optimal.

The statistical information on Exhibit 3.0 indicates that between 1984 and 1993 domestic dispute calls for service in terms of their number (N), average per response area (Mean), maximum number in a response area (Max.), and average calls received per day (Calls/Day) experienced tremendous increases. However, comparing the maps of domestic disputes calls for 1984 and 1993 delineates the spatial expression of the increases, thus making the changes more dramatic and tangible (Exhibit 3.0).

Exhibit 3.0 about here

During 1984, the response areas experiencing the highest frequencies of domestic dispute calls are in the northern, central and western portions of the city. The most conspicuous area producing calls lies on the west side of the city next to the airport. This is an area consisting of large public housing properties situated among other lower income neighborhoods. The other response areas exhibiting higher frequencies of domestic dispute calls are of similar circumstances

During 1984, areas around the periphery of city exhibiting zero domestic dispute calls were not part of the city but were later annexed. The other zero or blank areas are parts of the city that did not produce any domestic dispute calls during 1984. During 1993, all the response areas showing no domestic dispute calls are part of the city.

Comparing the maps for 1984 and 1993 reveals one major constancy and one major departure or change. The former being that the areas generating higher frequencies of domestic dispute calls during 1984 remain so during 1993. The latter is the tremendous expansion of domestic dispute calls across the whole city. First, numerically, the number of response areas producing zero or lower frequencies of domestic disputes has contracted greatly since 1984, or visually, the amount of space in white or darker tones is less during 1993. Second, the higher areas during 1984, are not only similar during 1993, but have expanded and coalesced with neighboring response areas. Finally, the most profound changes are in sections of the city that during 1984 produced middle range frequencies of domestic disputes (red tone areas) and have grown to become higher frequency responses areas. Three general sections of the city are most conspicuous. The first exhibits a corridor effect stemming from the northeast and running along

eastern portion of the city. The second is a large cluster of high frequency responses areas situated in the southwest side of the city. The third is a contiguous chain of high frequency clusters (green tone areas) emanating from the eastern side of the large cluster of response areas next to the airport (west side) and extending in a northeasterly arc (Exhibit 3.0).

Obviously, it is beyond the scope of this report to explain the underlying causes for the differences in the spatial patterns of domestic dispute calls across nine years. Mainly, because different processes have been simultaneously operating to create the different spatial patterns of domestic dispute calls for service.

Difference Maps

Another technique for seeing change through time is to simply subtract maps for two different time periods to produce a difference map. The raster data structure is ideal for performing basic mathematical operations. Furthermore, the GIS software will automatically scale and assign color codes to the values indicating changes in domestic disputes. Two difference maps are presented to illustrate this technique.

During, 1989, the number of domestic dispute calls increased by 3,889 from 25,011 during 1988 to 28,900 (Exhibits 1.0 & 4.0). The average change per response area was an increase of 7.2 calls. Overall, the range of change between 1988-1989 is 148 calls with a maximum decrease of 56 calls and increase of 91 calls (Exhibit 4.0). Between 1988-1989, 325 response areas accounted for an increase of 5,043 domestic dispute calls; 139 response areas recorded decreases totaling 1,154 calls while the remaining 73 response areas did not experience any changes from 1988 (Exhibit 5.0).

Exhibits 4.0 & 5.0 about here

Exhibit 6.0, which depicts the differences in domestic dispute calls between 1988 and 1989, allows one to visualize the spatial layout, direction, and intensity of changes across the city. The majority of response areas experiencing strong increases in disputes (red to green tones) are in the western and northern portion of the city. The exceptions are one response area in the southwest and another in the central portion of the city. The latter is a lower income minority neighborhood known as Grier Heights which experienced the greatest increase in domestic disputes (88). Furthermore, about 2.2 miles due north of Grier Heights is Piedmont Courts a public housing response area experiencing the second highest increase in domestic dispute calls (Exhibit 6.0).

Exhibit 6.0 about here

Obviously, the changes observed from Exhibit 6.0 may not have been as easy to discern if one was relying on tabular data. Likewise, other interesting spatial arrangements, which may have been obscured by tabular data emerge from a map. For instance, across Exhibit 6.0, one can observe several instances of response areas recording large decreases in close proximity to others experiencing sizeable increases. At the onset, one could argue a displacement effect, in that extra enforcement efforts at one place resulted in the activity moving to another location, but this not an offense or call for service involving strangers, thus it is very unlikely that displacement is an important factor.

During 1990, the number of domestic dispute calls increased by 1,439 from 28,900 during

1989 to 30,339 (Exhibits 1& 4). The average change per response area is an increase of 2.7 calls. Overall, the range of change between 1989-1990 is 290 calls with a maximum decrease of 129 calls and increase of 161 calls (Exhibit 4.0). Between 1989 and 1990, 249 response areas accounted for an increase of 3,731 calls; 220 response areas recorded decreases totaling 2,292 calls while the remaining 68 did not experience any changes from 1989 (Exhibit 5.0). Exhibit 7.0 shows the spatial distribution of the changes in domestic dispute calls for service between 1989 and 1990.

Exhibit 7.0 augments the tabular data by indicating that a majority of the map surface, hence a majority of the response areas experienced minimal increases and decreases of domestic dispute calls for service. Therefore, another important fact conveyed by the map is that a few response areas experienced extreme increases and decreases of domestic disputes. Finally, the range of the change between 1989-1990 was 290 calls for service and the two response areas representing the anchor points of the range (-129 and +161 calls) are the large public housing projects mentioned previously, located within a mile of each other on the west side of the city near the airport. In other words, Exhibit 7.0 shows two response areas which are traditional hot spots for domestic disputes and similar in their socio-economic and demographic composition during one year change in extreme opposite directions. The propinquity of the extreme response areas would lead one to examine if there was a different intervention or program in one response area and not the other or if the police were behaving differently in the two response areas.

Exhibit 7.0 about here

The difference maps allow one to visualize the numerical and spatial change of domestic dispute calls across an urban landscape. Therefore, illuminating the intensities, distances, and directions of changes among response areas. Nevertheless, as useful as this type of mapping might be for localizing numerical change there is still a need for isolating response areas of significant change.

Threshold Maps

The difference maps depict absolute change across the city. Yet, at times it might be valuable to ascertain, in a statistical sense, which response areas have experienced a significant statistical change in domestic dispute calls for service. A technique for achieving this, that is available in most GIS and computer mapping packages is thresholding. Thresholding involves examining the data to be mapped and determining which data values are average change or normal change and which values represent extreme or significant change. Thus, upper and lower limits are established representing normal variation and data points beyond the limits are significant change (See, Eastman and McKendry, 1991: 29).

Thresholds are established for the same data and time periods used in the difference maps. The threshold is based on the normal curve and two standard deviations. Thus, three categories emerge: average change or normal variation is change between -2.0 standard deviations and +2.0 standard deviations; extreme decrease is change that is less than -2.0 standard deviations; and extreme increase is change greater than +2.0 standard deviations. average change, extreme decrease and extreme increase. According to statistical theory 95% of all the responses areas are expected to experience average change while changes less than -2.0 and greater than +2.0

standard deviations are considered unusual.

Fortunately, the thresholds for the changes for 1988-1989 and 1989-1990 are almost identical 42 domestic dispute calls for the former contrast and 42.1 for latter. The thresholds are calculated by adding the mean to double the standard deviation (Exhibit 4.0). The thresholds are mapped for the changes between 1988-1989 and 1989-1990 in Exhibit 8.0.

The threshold maps allow one to isolate the response areas experiencing extreme change. The response areas that were nominated as being extreme in the discussion of difference mapping emerge in the threshold mapping. Furthermore, it was stated previously that more response areas between 1988-1989 increased in domestic dispute calls than between 1989-1990. Exhibit 8.0 shows that more response areas experienced extreme increases during 1988-1989 than 1989-1990.

Exhibit 8.0 about here

Obviously, the majority of response areas experienced average change from 1988-1989 & 1989-1990 (Exhibit 8.0). If one compares the two maps it is apparent that some response areas during the earlier contrast (1988-1989) experienced average change but during the later contrast(1989-1990) yielded extreme increases or decreases. Furthermore, one can see that some response areas producing extreme changes during the early contrast will experience extreme changes in the same or opposite direction during the later contrast. For example, examining the western portion of the city one can see two response areas during 1988-1989 producing extreme increases, yet between 1989-1990, one response area continues to increase while the other yields

an extreme decrease. This situation was discussed in the section on difference maps, but the issue raised by the the threshold maps is the fluctuation of response areas through time or the spatial volatility of domestic dispute calls through time. Fortunately, there is a mapping solution that will help us visualize spatial volatility.

Cross Classification Maps

The raster based structure of the GIS used in this study permits us to take the threshold maps in Exhibit 8.0 and cross classify them to produce one map (Exhibit 9.0). The new map shows the *Spatial Volatility of Domestic Disputes 1988-89-90*. Theoretically, there are nine possible classifications or categories, but with these data there are not any response areas experiencing consecutive decreases (Decrease to Decrease) nor going from a decrease to an increase (Decrease to Increase).

Exhibit 9.0 about here

The initial impression after reviewing the map of *Spatial Volatility of Domestic Disputes 1988-89-90* is the same one reached after reviewing the threshold maps (Exhibit 8.0) - the majority of the response areas consistently experienced average change. The map shows spatial biases in the consistently average areas: there is a very large wedge shaped area emanating from the central northwest portion of the city then fanning out to the southern and southeastern portions of the city; and other similar areas lie in the northwestern, northeastern, and southwestern sections of the city (Exhibit 9.0). After describing and reviewing the average areas

it is possible to discern the spatial arrangements of the response areas experiencing at least one episode of significant change through the years.

The areas experiencing extreme change (*Increase to Decrease* and *Increase to Increase*) are spatially restricted. Only three response areas consistently experienced increases: one is in the north; another, alluded to previously, is in the west; and the third is situated in the southern portion of city almost directly due south of the first area described. However, its the changes of the response areas around or near these three areas that provide inferences as to the dynamics or volatility of these areas. For example the northern response area is surrounded response areas consistently experiencing average change, thus indicating that intervention efforts should be focused solely one response area. The southern response area is more volatile and problematic because to its north are two response areas experiencing *Average to Increase* change. Thus, indicating response areas where the combination of conditions yielding more domestic disputes are correct. Therefore, requiring that intervention efforts will have to be focused at several places. The situation on the west side of the city is different from the others. Contiguous with the *Increase to Increase* response area are others experiencing *Increase to Average* and *Average to Increase* changes and to the immediate west is only response area that went from *Increase to Decrease*. This propinquity of response areas experiencing different and extreme changes indicates, that in this general region, domestic dispute calls for service may not be a unitary concept and that intervention efforts may have to be more diverse because the volatility is more complex (Exhibit 9.0).

Finally, the majority of response areas experiencing *Increase to Average* and *Average to Increase* change exhibit an interesting spatial arrangement. The latter group exhibits a corridor

pattern running from the north central portion of the city to the southeast and is surrounded by *Increase to Average* response areas. This positioning suggest that perhaps the conditions promoting significant increases in domestics dispute calls between 1988-1989 may have diffused toward the center of the city between 1989-1990.

Prospects For This Type of Mapping

Obviously, in another publication medium or in a real world operational setting maps such as those presented here would be modified with additional details such as coverages of pertinent administrative or areal boundaries (i.e, precincts, neighborhoods, and census tracts) and complemented with maps of other correlative information (i.e., census, land use, zoning). Thus, this discussion had been handicapped by trying to present the fruit of a novel technology through a traditional medium.

Raster based mapping and GIS hold great promise for further describing, defining, and analyzing crime in its ecological setting, however, it should not be viewed as a panacea or the ultimate mapping solution. For a fundamental problem with mapping in criminal justice is that there have been numerous attempts to answer operational, policy, and research questions with the wrong or less-than-optimal mapping technology. The major benefit of raster, cell, or grid based mapping is its structure which allows one to perform mathematical operations on maps, but it is still the research question that should be the important determinant for selecting a mapping solution.

If the questions pertain to assessing hazardous intersections, watching places, tracking offenders, monitoring specific or low frequency crimes, or making tactical short term decisions

then a vector based mapping would be better because the questions emphasize a smaller scale or specific locations, shorter time span, and lower frequency of events. The raster format is better for questions pertaining higher frequency crimes or calls, larger geographic units (i.e, census block groups, census tracts), and strategic planning and long-term decision making.

Computer mapping, geographic information systems, and spatial analysis can be applied to a vast array of problems in criminal justice. However, in order for these tools to be useful it is important for the users to become familiar with the concepts and principles governing their use. As Mark Monmonier admonishes in his work *Mapping It Out: Expository Cartography for the Humanities and Social Sciences*:

Yet graphics software no more guarantees good maps than word-processing software assures good writing.....

Beware of software products that promise instant maps. Unfortunately for many would-be map makers, not all developers of mapping software are aware of the principles of cartographic design. (1993: 12)

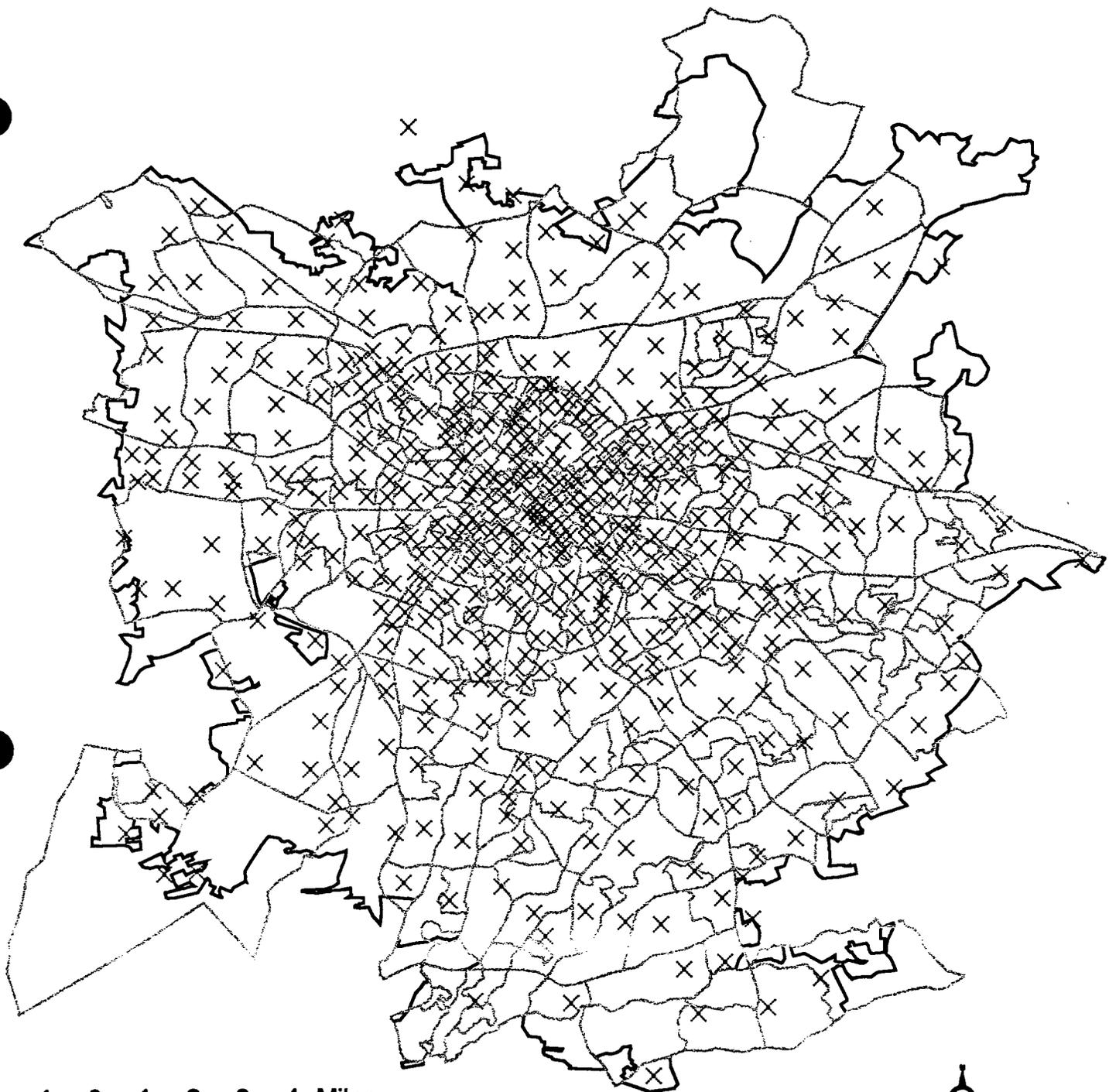
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Exhibit 1.0: Total Calls For Service and Domestic Disputes

Year	Calls For Service	Domestic Disputes	Percent Domestic
1984	247,048.00	18,733.00	7.58
1985	262,838.00	18,380.00	6.99
1986	288,815.00	20,840.00	7.22
1987	307,052.00	21,552.00	7.02
1988	333,484.00	25,011.00	7.50
1989	322,164.00	28,900.00	8.97
1990	382,923.00	30,339.00	7.92
1991	384,370.00	30,199.00	7.86
1992	412,845.00	32,570.00	7.89
1993	435,860.00	32,952.00	7.56
Total	3,377,399.00	259,476.00	7.68

Exhibit 2.0: *Response Area Centroids Within Census Block Groups*

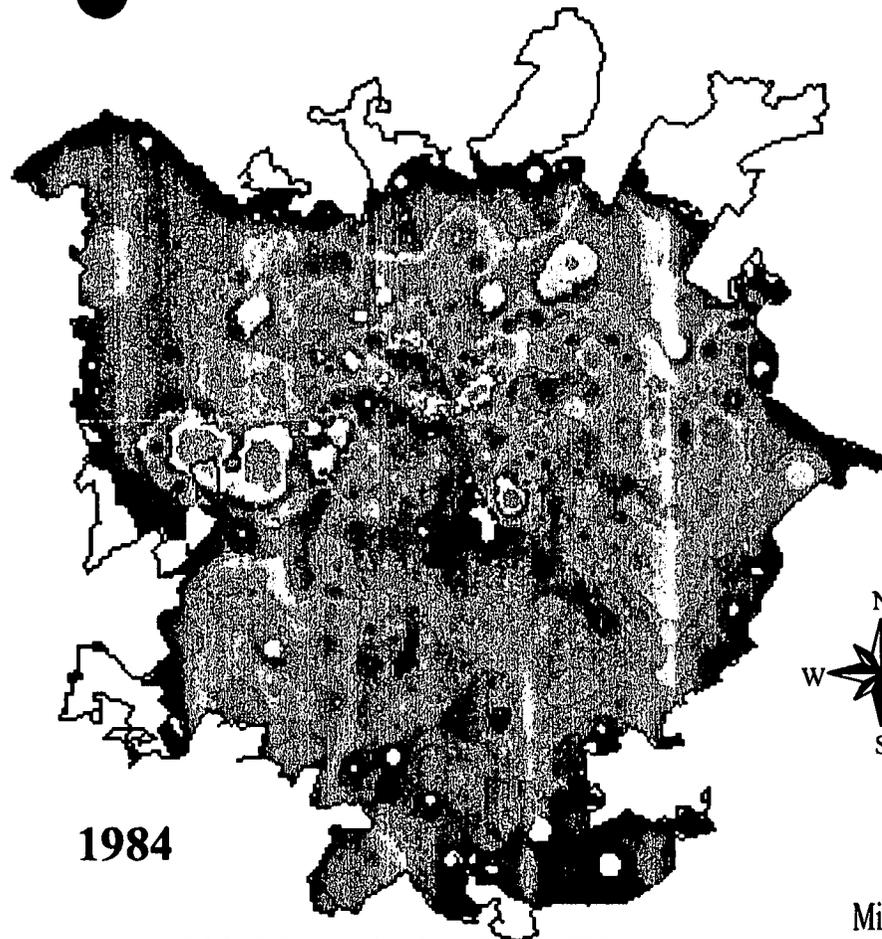


1 0 1 2 3 4 Miles

- × Response Area Centroids
- 1990 Census Block Groups
- Charlotte City Limits

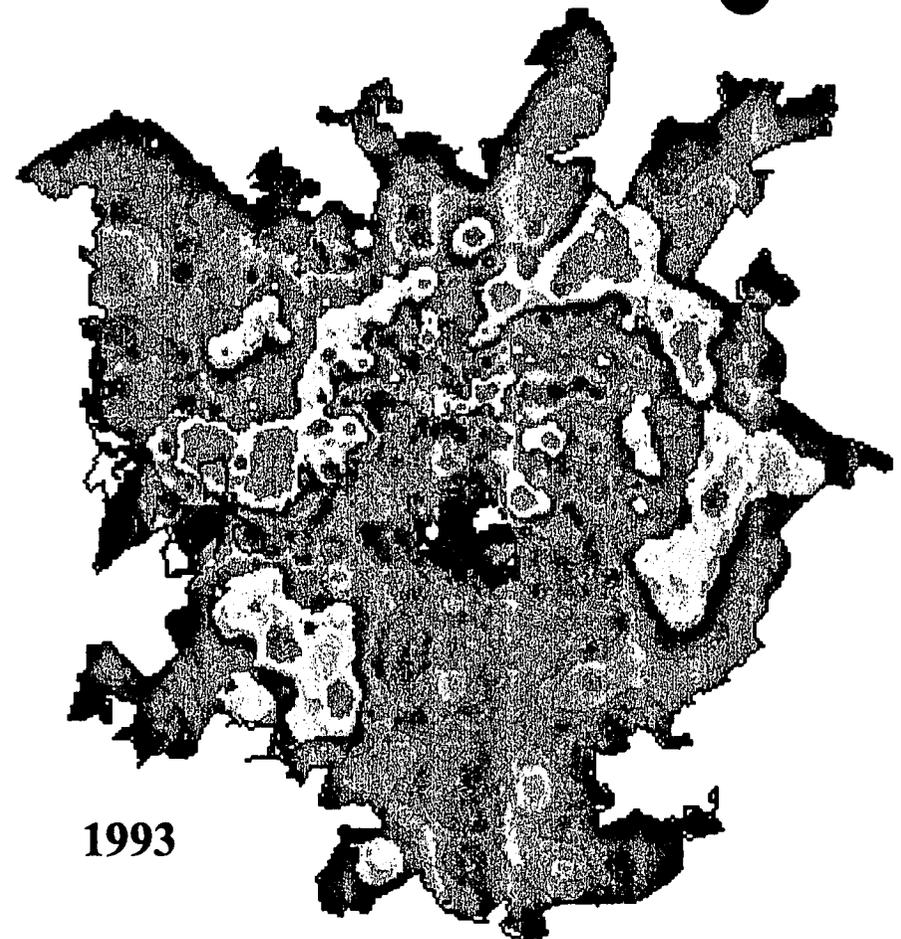
**Response Area Centroids Within
Census Block Groups:
Charlotte, North Carolina (1993)**

Exhibit 3.0: *Domestic Dispute Calls For Service: 1984 & 1993*



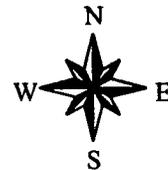
1984

**N=18,733; Mean=34.8; Max.=679
Calls/Day=51.18**

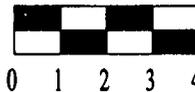


1993

**N=32,952; Mean=61.4; Max.=916
Calls/Day=90.27**



Miles



Square Root



0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 >=16

Domestic Dispute Calls For Service: 1984 & 1993

**Exhibit 4.0: Statistics of Changes in Domestic Dispute
Calls: 1988 - 1989 & 1989 - 1990**

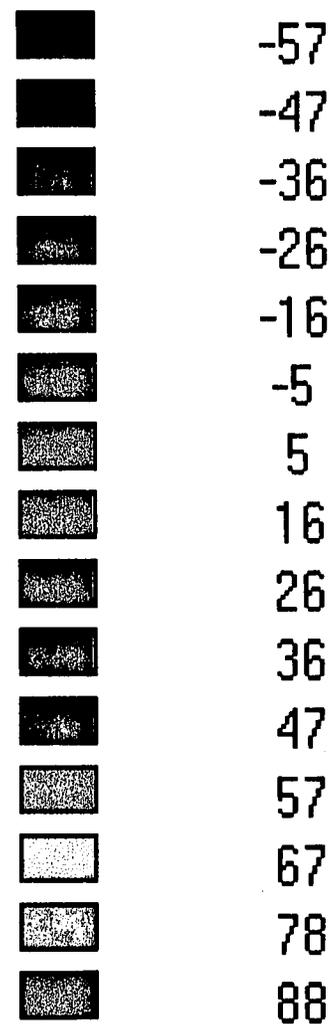
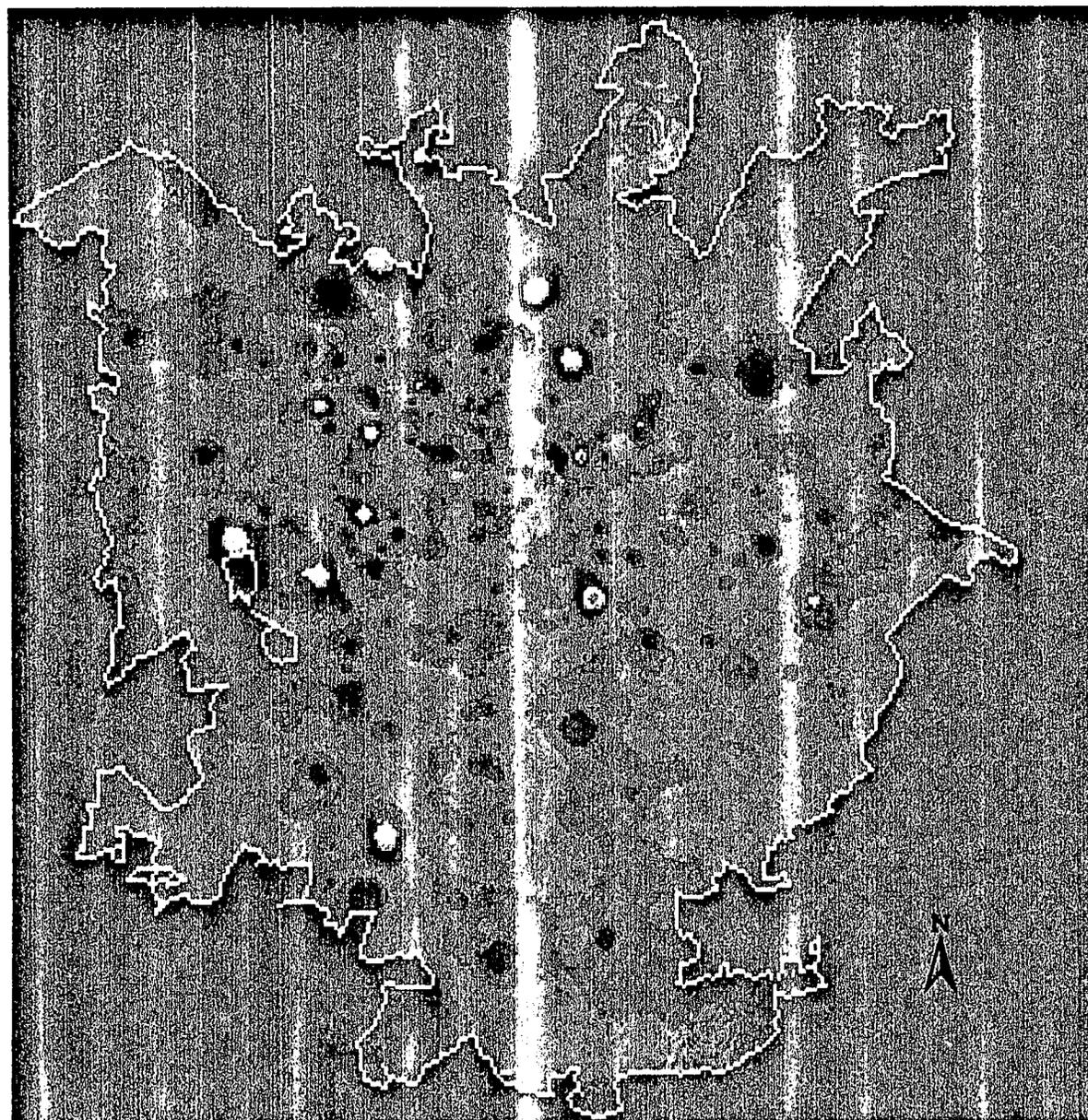
	1988-1989	1989-1990
Mean/Response Area	7.2	2.7
Standard deviation	17.4	19.7
Range	148	290
Max. Decrease	57	129
Max. Increase	91	161
Total Change Calls	3,889	1,439

**Exhibit 5.0: Response Area Changes in
Domestic Dispute Calls**

	1988-1989	1989-1990
Change in Calls	N Response Areas	N Response Areas
Increase (# calls)	325 (5,043)	249 (3,731)
Decrease (# calls)	139 (1,154)	220 (2,292)
No Change	73	68

Exhibit 6.0: *Difference In Domestic Disputes: 1988 - 1989*

Number of Disputes



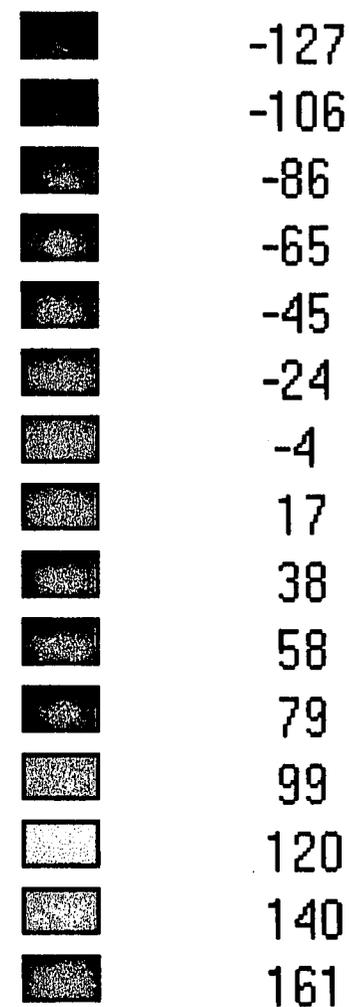
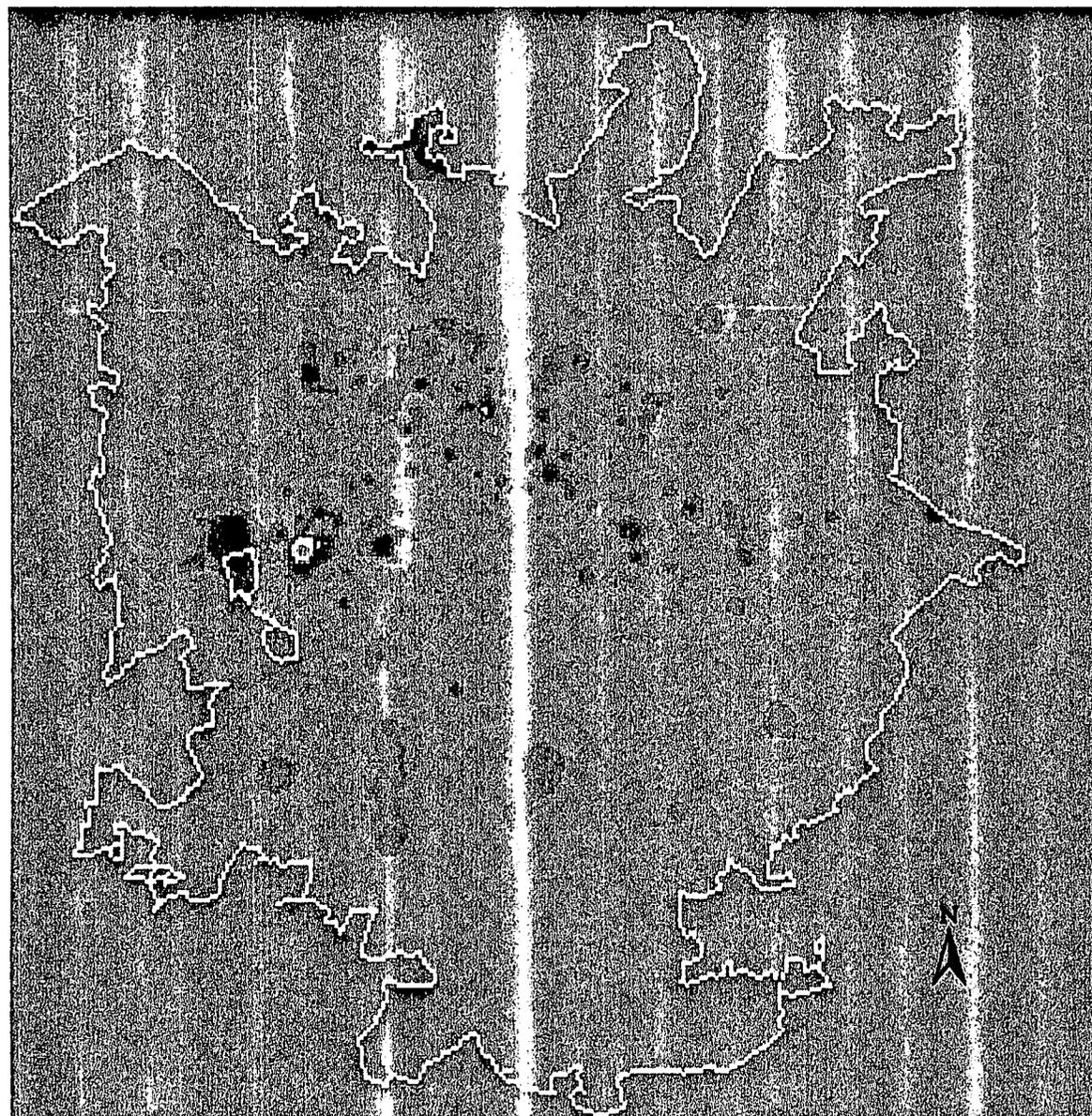
Miles



Difference In Domestic Disputes: 1988-1989

Exhibit 7.0: *Difference In Domestic Disputes: 1989 - 1990*

Number of Disputes

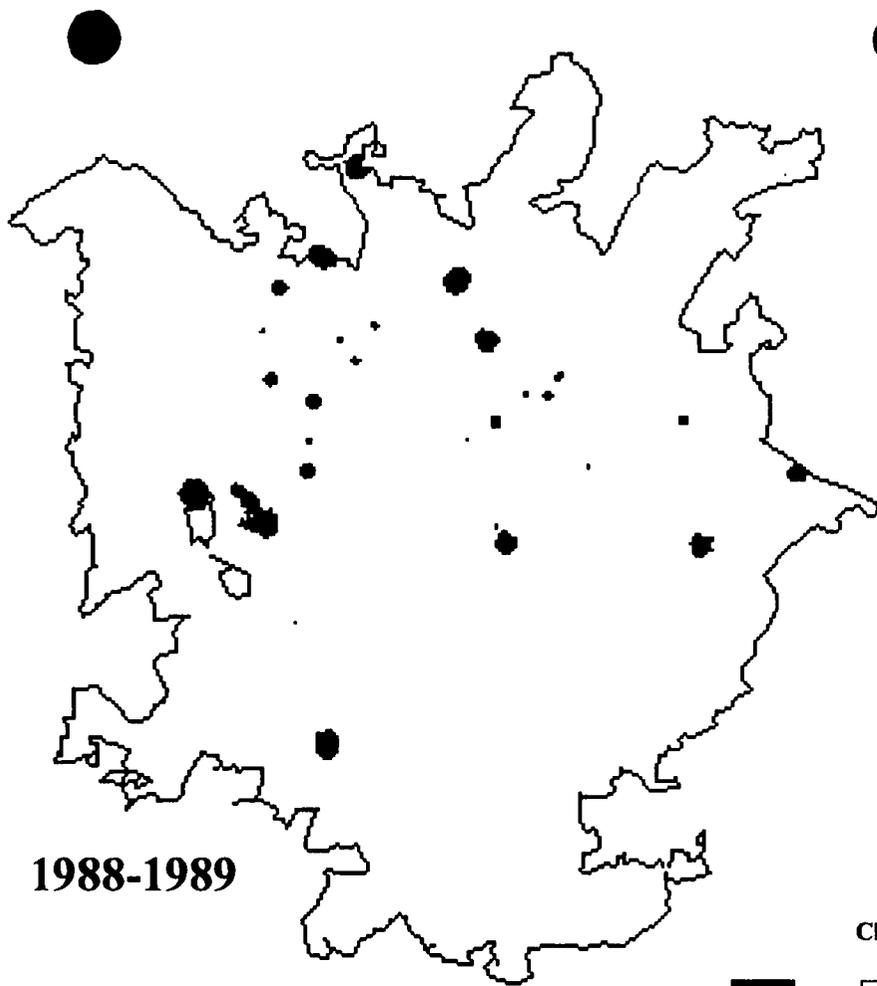


Miles

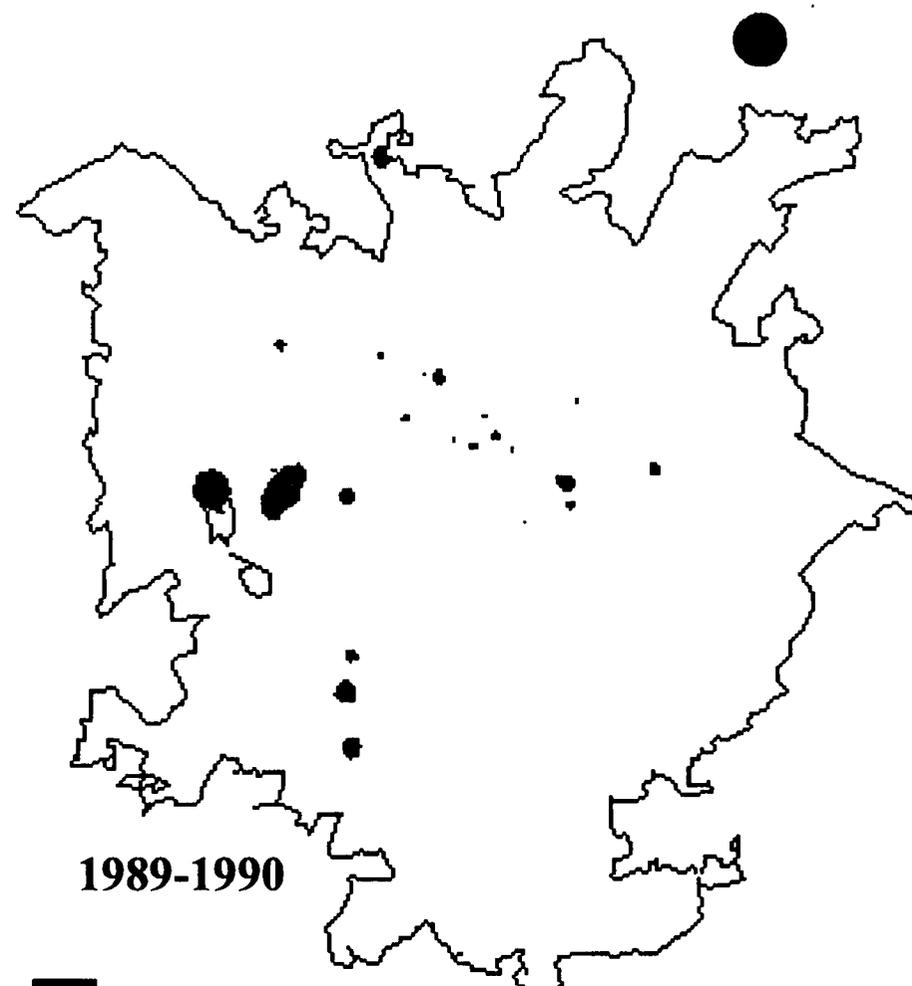


Difference In Domestic Disputes: 1989-90

Exhibit 8.0: Threshold Maps



1988-1989



1989-1990



Change



Extreme Increase

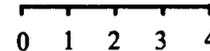


Average



Extreme Decrease

Miles



Threshold Maps

Areas of Extreme Change in Domestic Disputes

Exhibit 9.0: Spatial Volatility Of Domestic Disputes: 1988-89-90

Spatial Volatility Of Domestic Disputes

1988-89-90



Average to Decrease



Increase to Decrease



Decrease to Average



Average to Average



Increase to Average



Average to Increase



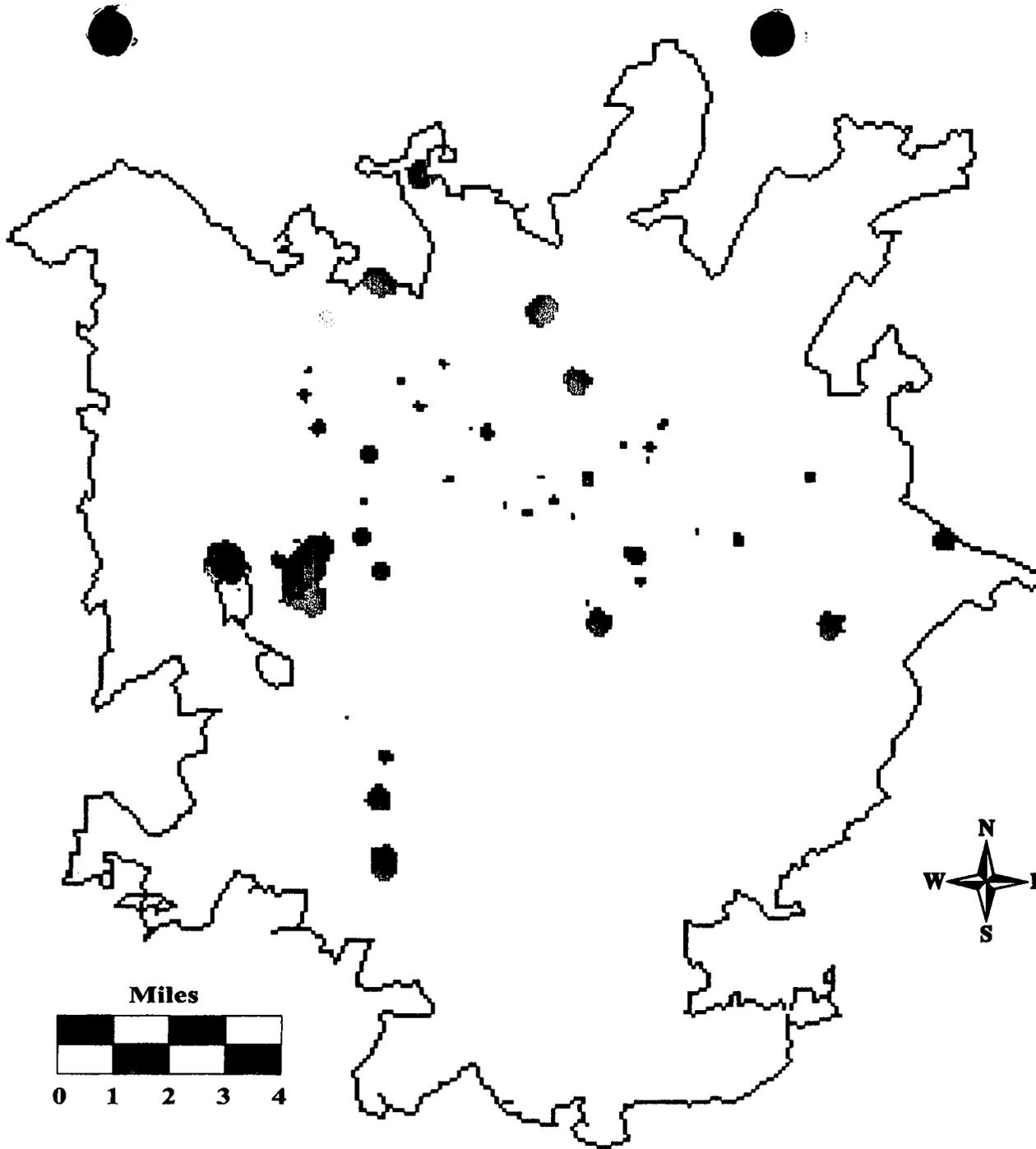
Increase to Increase



Miles



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