Demonstrating The Analytical Utility of GIS for Police Operations

A Final report

by

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Disclaimer

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Demonstrating the Analytical Utility
of
Geographic Information Systems for Police Operations

Overview

This is the final report of a project involving a partnership between the Charlotte-Mecklenburg, North Carolina Police Department and Southern Illinois University at Carbondale. Three modules or projects are discussed.

The first involves a different manner for visualizing the distribution and change of crime and calls for service by altering the size and/or color of street segments according to their intensity of crime and/or calls for service. This is called the *Safe Streets* approach. The second involves two models for assessing, analyzing, and mapping *Hazardous Space* for police work. The third involves using GIS and non-police external data for analyzing the police response to *Special Events* or, in this example, a natural disaster like a flash flood.

Caveats placed on the project by the P.I. were that all the techniques must be simple and easily understood by future users. Moreover, no exotic hardware or software must be used. Both must be standard off-the-self items or easily accessed through the Internet.

Visualization: Seeing Things Differently

This module is concerned with demonstrating how GIS and cartographic design are used for visualizing and assessing the changes of crime and specific calls for service across time and urban space. Intoxicated pedestrians and drug arrests are the two problems examined in this module.

Figure 1.0 depicts the street locations of intoxicated pedestrian arrests in the downtown section of Charlotte, North Carolina known as Uptown for 1990 and 1997. The intersection of Trade and Tryon Streets represents the center of the city. The statis-

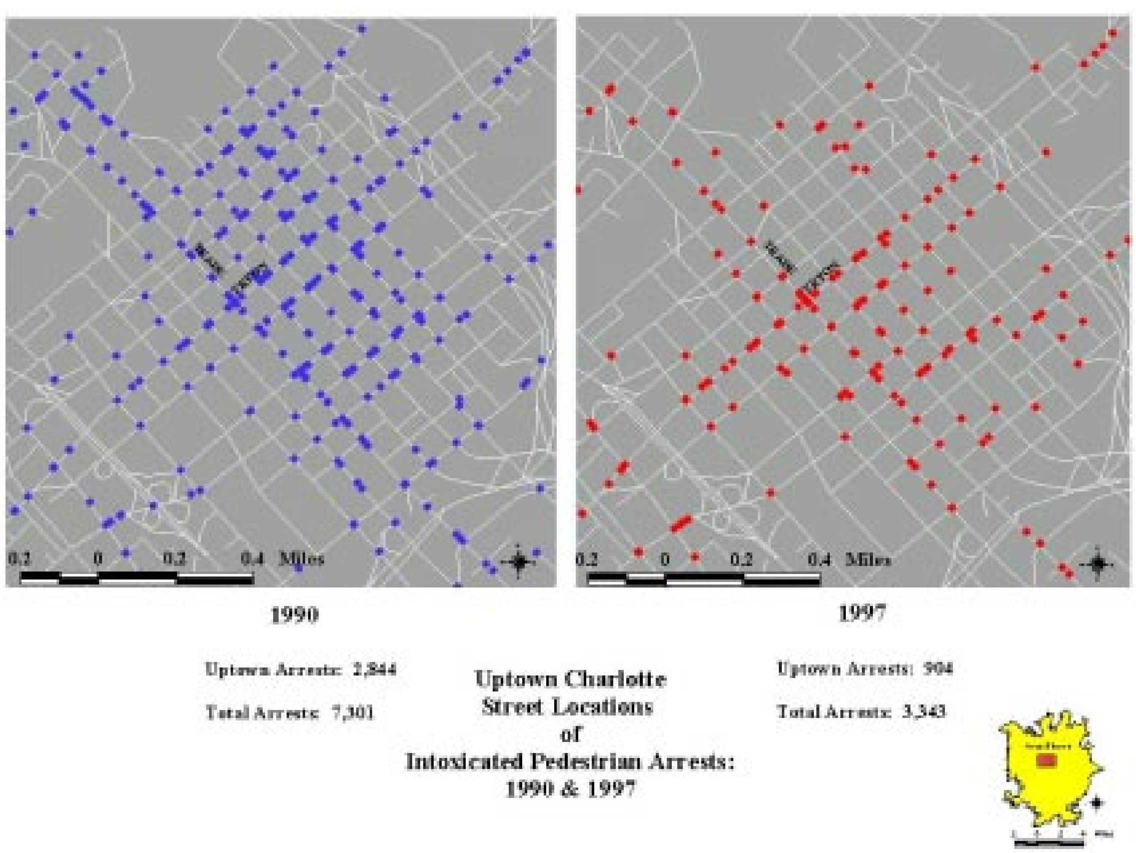


Figure 1.0

tical information indicates a tremendous decrease in the number of arrests between the two years. Jurisdiction wide, the number of arrests decreased by 54 percent. Uptown's arrests decreased by 68 percent. Moreover, Uptown's proportion of the total arrests decreased from 38 percent to 27 percent. The numerical evidence suggests profound differences between the years. Likewise, comparing the maps for the two years suggest a profound geographical change (Figure 1.0).

There are fewer dots or arrest locations during 1990 over 1997. An area of six square blocks immediately north of the intersection of Trade and Tryon produces no arrests during 1997, while during 1990, this area was infested with arrests. Figure 1.0 is an example of basic mapping and analysis whereby the street-block addresses of crimes or calls are geocoded and icons or dots are used to mark the locations of these events with the analysis involving a visual inspection and interpretation of the maps.

These maps, because of their designs, do not impart as much information about the geographical change of intoxicated pedestrians arrests in the Uptown area. The point locations are not accurate. The algorithm for geocoding an address from Tiger Street files involves taking the block number of the address and interpolating its position between a beginning and ending block range for the street segment regardless of the actual spacing between and among the addresses and parcels on a segment (U.S. Census, 1997 ; Harries, 1999). An alternative is to match address locations with a file of the coordinate pairs for property parcels. Hot spots and repeat addresses can be ascertained with spatial statistical software and visually represented with techniques like graduated symbol mapping. Yet, the volume and propinquity of the incidents may hamper the production of a map that is not too cluttered or noisy.

A common practice has been to aggregate the point locations into larger areal units such as census block, groups, tracts or police districts. Such aggregations might be more convenient and meaningful for managers and produce simpler maps for interpretation but two properties associated with the modifiable areal unit problem (MAUP) handicap this practice (Openshaw, 1983). The first, known as the scale problem, predicts that the same variables analyzed at different levels of aggregation will produce varying results. This problem has serious implications for long term planning, policy, and causal analysis. The second, known as the zonation problem, is concerned with the varying results when point locations are allocated into larger areal units of the same scale in different ways (Green and Flowerdew, 1996). Monmonier (1996) demonstrated this problem by allocating the point locations of Dr. Snow's cholera victims in London during 1854 into three different areal configurations at the same scale (See, Tufte, 1997: 27-37). Each configuration yielded a different geographical pattern of the cholera problem. Therefore, with the zonation problem, it is possible to place point locations into larger geographical units and completely hide, distort, or define problem areas (See, Monmonier, 1996: 158). Overcoming these problems require a visualization solution which simultaneously allows one to assess the magnitude and fluctuation of a crime problem without overly distorting its location.

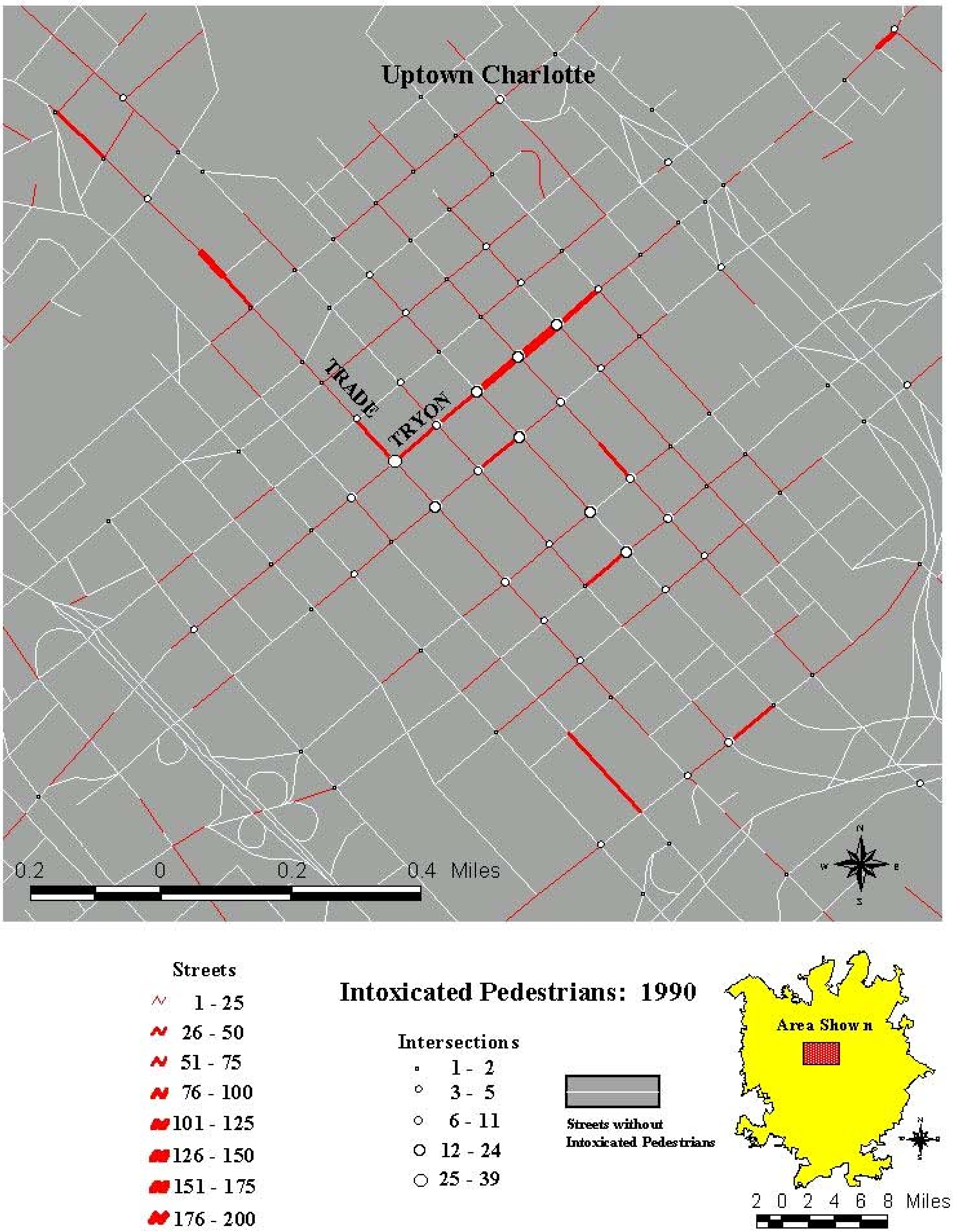
The solution to this problem involves aggregating the point locations to a feature that is smaller than the usual areal units such as census tracts or police districts. The definition of this feature should be uniformly understood. For example, the definitions and dimensions of police districts, beats, or response areas vary from jurisdiction to jurisdiction. Features like street segments and intersections, because they are the daily navigational aids for patrol officers, are more uniformly understood. The street segment or intersection as the unit of analysis was used in the pioneering work on policing drug hots spots (Weisburd and Green, 1994 & 1995). However, this project augments the earlier work by providing a more precise method for mapping.

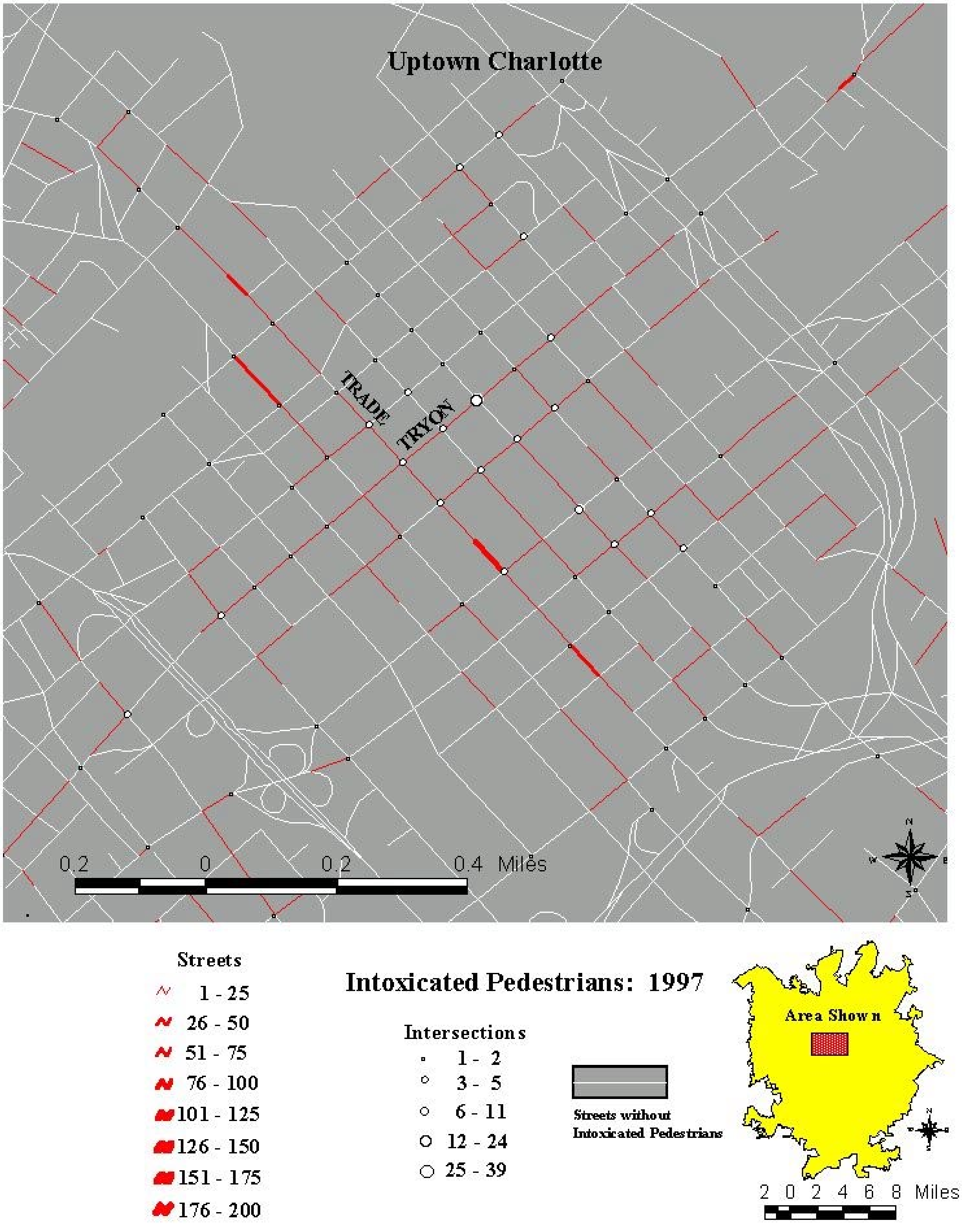
Intoxicated pedestrian arrests are usually outdoor incidents. The recorded locations for the arrests are usually street block locations, however, many incidents use street intersections as a spatial reference. The intersection often may be the default location recorded because an individual is arrested some where along the street but not near a readily identifiable specific address. The point locations in this demonstration will be aggregated into street intersections and segments. The attribute for mapping will be the number of intoxicated pedestrian arrests for each intersection or street segment.

There are two steps in this procedure. The first involves address matching all the arrests recorded at intersections. The X,Y coordinates for each incident are retrieved by using the *View.AddXYCoordToFTab* script. Unique intersections are identified by truncating the coordinates into whole numbers and concatenating the whole numbers for the X,Y coordinates into a single number. Thus, creating a unique identifier for each intersection. The intersections are summarized by identifier creating a new coverage with the total number of arrests for each intersection.

The second step is related to the common point-in-polygon procedure in ArcView. Instead of measuring the number of points within a polygon or areal unit, a point-on-line match is conducted measuring the number of arrests on each street segment. The latter procedure, which we call *Safe Streets,* has been used in other applications. We are trying to expand its use in crime mapping.

Figure 2.0 depicts the spatial distribution of intoxicated pedestrians during 1990 in Uptown Charlotte. This is a graduated symbol map with intersection size varying with the frequency of arrests. This representation technique is fairly common, however, varying the size of the street segments according to arrest frequency is not common. Graduating the sizes of the intersections and streets allows one to easily ascertain where intoxicated pedestrian problems are more prevalent. Moreover, it is just as informative to





Uptown Charlotte
TRADE
TRYON
0.2
0
0.2
0.4 Miles
Streets
1 - 25
26 - 50
51 - 75
76 - 100
101 - 125
126 - 150
151 - 175
176 - 200
Intoxicated Pedestrians: 1997
Intersections
1 - 2
3 - 5
6 - 11
12 - 24
25 - 39
Streets without Intoxicated Pedestrians
Area Shown
2 0 2 4 6 8 Miles

Figure 3.0

It is possible to create a difference map by subtracting one map from the other. Thus, creating Figure 4.0, which is the *Change in Intoxicated Pedestrians: 1990-1997.*

Exhibiting the spatial distribution of change complicates the visualization representation. First, in order to make comparisons across the years, the same legends are used for calibrating the frequencies of arrests in intersections and street segments. Second, mapping out the totality of change requires not only mapping out the increases and decreases of arrests on streets and in intersections, but depicting those features which had the same number of arrests during both years and those that did not have any arrests. Finally, the changes have to be represented by colors that easily communicate the direction of the change to the map-reader.

In Figure 4.0, the streets and intersections are graduated in size in order to represent the magnitude of change. The color scheme represents the type or direction of change. Red, because the color is a metaphor for fire or hot temperatures, represents an increase. Blue, as a metaphor cooling or colder, represents a decrease. Yellow represents the features that experienced the same number of arrests between the years. Streets and intersections that did not have any arrests are represented in light gray.

Figure 4.0 confirms what was gleaned from comparing Figures 2.0 and 3.0. There is a dramatic decline in intoxicated pedestrian arrests along the segments and intersections of Tryon and West Trade Streets. The majority of intersections and segments experiencing arrest increases are to the south, east, and west of this major intersection. For example, the large increasing street segment on E Trade St between two decreasing intersections and contiguous to a street segment reporting the same number of

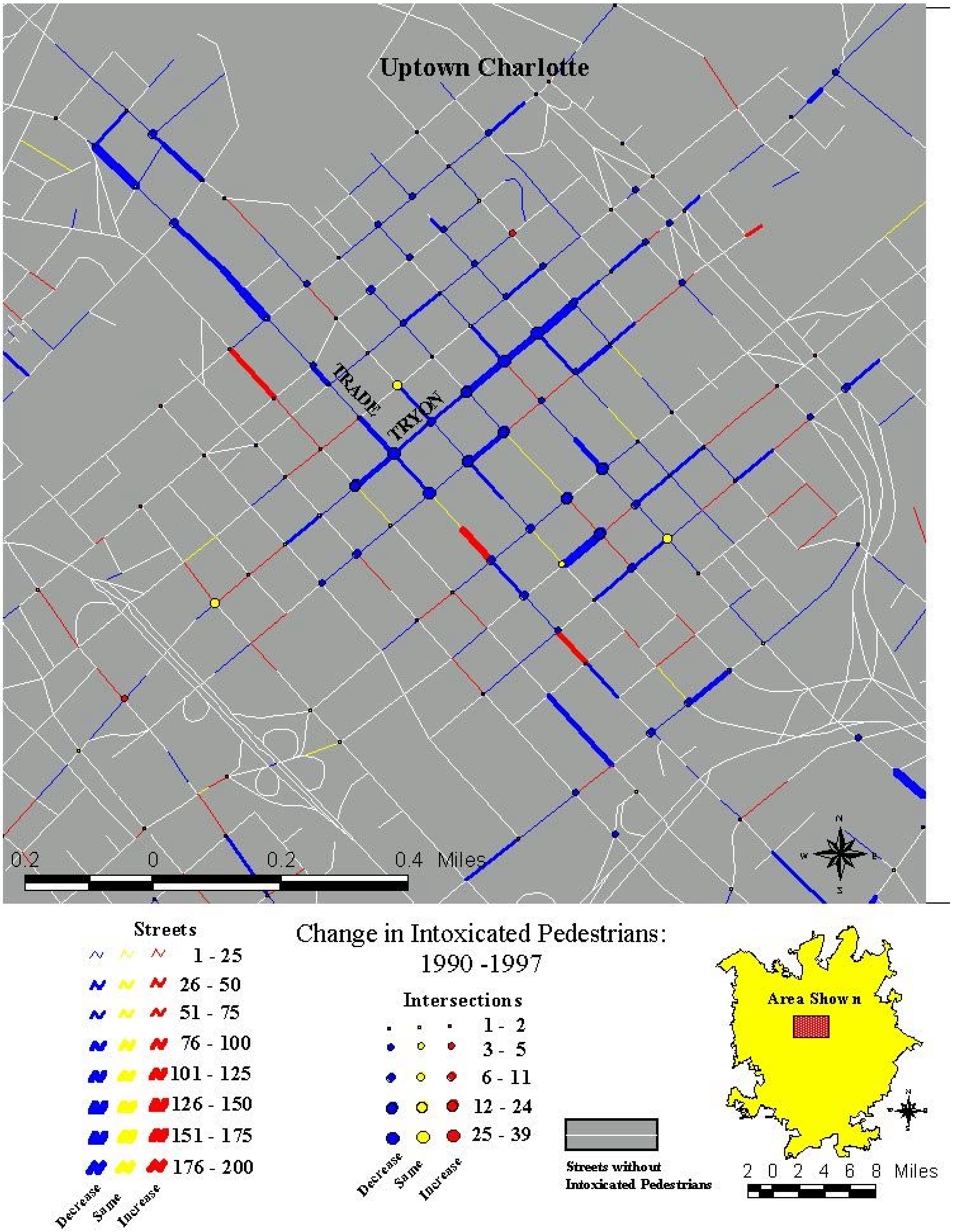

Uptown Charlotte
TRADE
TRYON
0.2 0 0.2 0.4 Miles
Streets
1 - 25
26 - 50
51 - 75
76 - 100
101 - 125
126 - 150
151 - 175
176 - 200
Decrease Same Increase
Change in Intoxicated Pedestrians: 1990 -1997
Intersections
1 - 2
3 - 5
6 - 11
12 - 24
25 - 39
Decrease Same Increase
Streets without Intoxicated Pedestrians
Area Shown
2 0 2 4 6 8 Miles

Figure 4.0

arrests is the Charlotte Transportation Center, which is the major hub for the city's public bus system. It is difficult to assess the factors that are responsible for the dramatic reduction in intoxicated pedestrian arrests. Several factors are possible including new construction removing the places for intoxicated pedestrians to linger and CMPD enforcing an open bottle ordinances.

Mapping out intoxicated pedestrian arrests may not be an important call for service to examine but this mundane problem was excellent for demonstrating the visualization technique. The next discussion applies the *Safe Streets* technique to the more frequent and serious problem of drug arrests

Mapping Out Drug Arrests

Drug arrests during 1997 and 1998 are mapped using the *Safe Streets* technique. This illustration is divided into three parts. The first is similar to the discussion of intoxicated pedestrians and focuses on the annual depictions of the counts of drug arrests across street segments and the difference between the years. The second uses a different metric for mapping drug arrests. Instead of counts or frequencies, drug arrests are expressed as arrests per street segment mile. A change or difference map between the years and a second map depicting change in terms of standard deviational units have been constructed. The final portion discusses this type of mapping as a graphical technique for measuring and visualizing displacement. Specific neighboring street segments registering opposite extreme changes are nominated as examples of spatial displacement.

During 1997 and 1998, there are 5,056, and 5,211 drug arrests respectively. Viewed in another way: out of the 34,463 street segments in Charlotte-Mecklenburg County, 2,056 had at least one drug arrest during 1997. The number of drug arrest segments increases to 2,158 during 1998. These simple statistics imply that drug arrests increased and moved from 1997 to 1998. Mapping drug arrests with the *Safe Streets* technique helps one to see the geographic distribution and change in drug arrests.

Figure 5.0 is the number of drug arrests by street segments during 1997. The segments experiencing arrests are in red and the number of arrests graduates the width of the segment. The area depicted in the maps has experienced the majority of the drug arrest for both years. This area includes the *Uptown* section examined in the previous discussion of intoxicated pedestrians and other neighborhoods of the Charlotte central core.

The inset shows the area depicted in relation to the total jurisdiction of the Charlotte-Mecklenburg Police Department. The blue lines and yellow letters are the boundaries and designation of the Bureau-District-Response areas (BDR). Patrol operations are organized along four Bureaus (see map inset). These are divided into approximately 12 districts with each district divided into 4 to 9 response areas. Therefore, *D12*, means that the polygon is David Bureau's District 1, Response Area 2.

According to Figure 5.0, there are many street segments with drug arrests, during 1997, however, some standout more than others. The wide street on the west side of BDR D32 is Willis Street which runs through the Piedmont Courts Public Housing Project. There were 48 arrests during 1997. Another anomaly appears in D11. The large street southwest of the label is Fourth Street and the address generating 76 drug arrests is the Mecklenburg County Jail. These arrests were made elsewhere but the jail address was used as the default address. Therefore, this is a false hot spot. There are many street segments in Figure 5.0 experiencing drug arrests.

Figure 6.0 depicts drug arrests during 1998. The legends and data scales are the same as Figure 5.0. Therefore, it is easier to compare changes in the geographic distribution of drug arrests. The anomalies appearing during 1997 are similar during 1998, however, there are other segments which have emerged with higher frequencies. Most conspicuous is the segment on the border between BDRs D14 and D13 in the west central portion of the map. Moreover, other segments have increased in other BDR's (e.g., A21 and D25). Figures 5.0 & 6.0 are clearer pictures of the spatial variation of drug arrests for each year. Constructing a difference or change map provides a more precise visualization of changes.

Figure 7.0 depicts the segment changes in drug arrests between the two years. Again red indicates an arrest increase; yellow the same numbers of arrests between the years; while black depicts a decrease. Obviously, because this is a change or difference map, the high frequency arrest segments for each year are not presented. Using Figures 5.0 and 6.0 as baselines, Figure 7.0 shows the magnitude and direction of change across the segments.

The previously discussed Piedmont Courts area in D32 records an arrest decrease. The Mecklenberg County Jail in D11 exhibits a moderate increase, while the street segment on the border between D13 and D14 indicates a tremendous increase. This segment is the 1000 –1098 block of South Tryon Street and two lower scale motels on

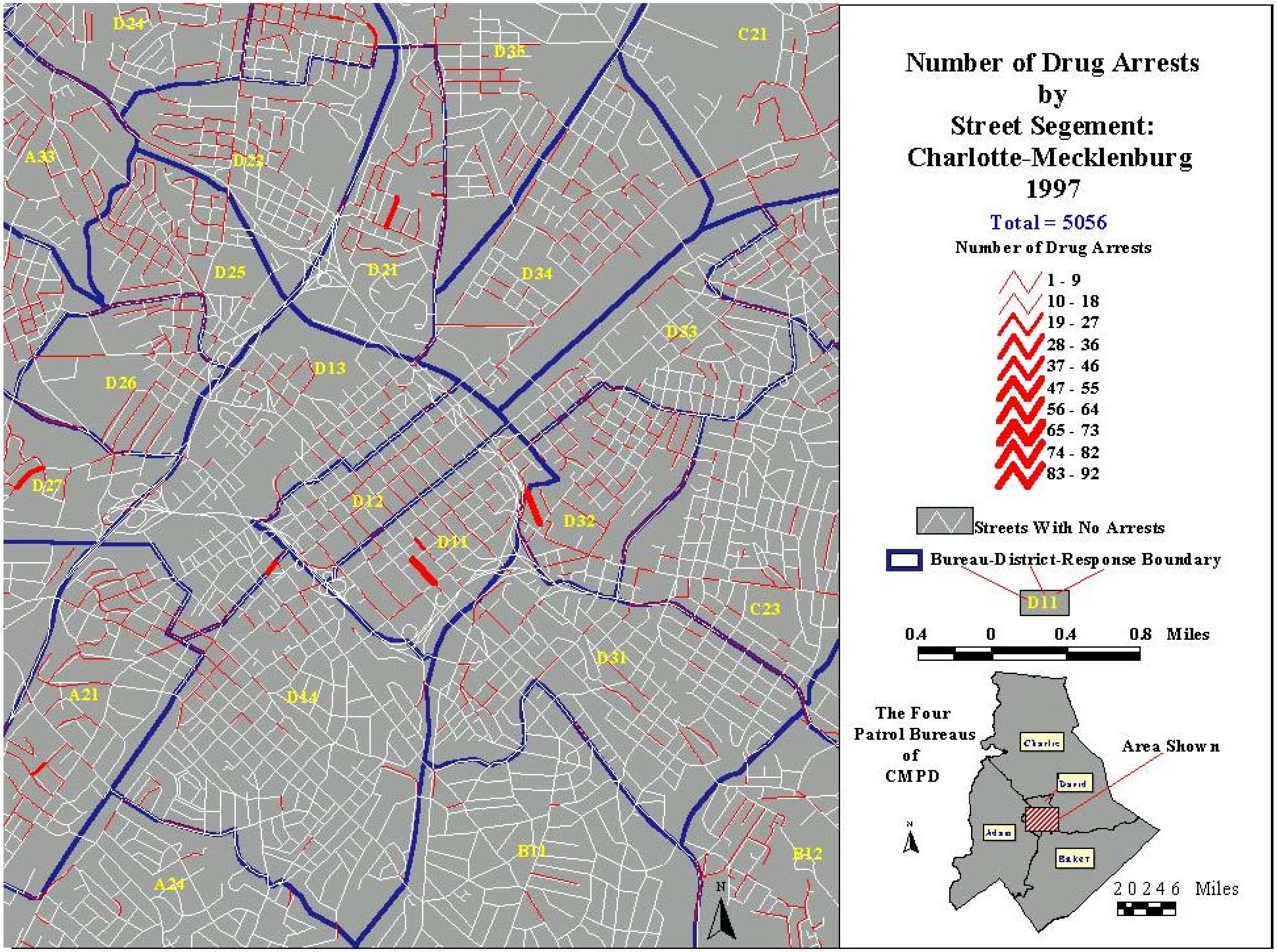

Number of Drug Arrests
by
Street Segement:
Charlotte-Mecklenburg
1997
Total = 5056
Number of Drug Arrests
1 - 9
10 - 18
19 - 27
28 - 36
37 - 46
47 - 55
56 - 64
65 - 73
74 - 82
83 - 92
Streets With No Arrests
Bureau-District-Response Boundary
D11
0.4 0 0.4 0.8 Miles
The Four
Patrol Bureaus
of
CMPD
Charlie
David
Adam
Baker
Area Shown
2 0 2 4 6 Miles
N
D24
D35
C21
A33
D22
D25
D21
D34
D33
D13
D26
D27
D12
D11
D32
C23
D31
A21
D14
B11
B12
A24

Figure 5.0

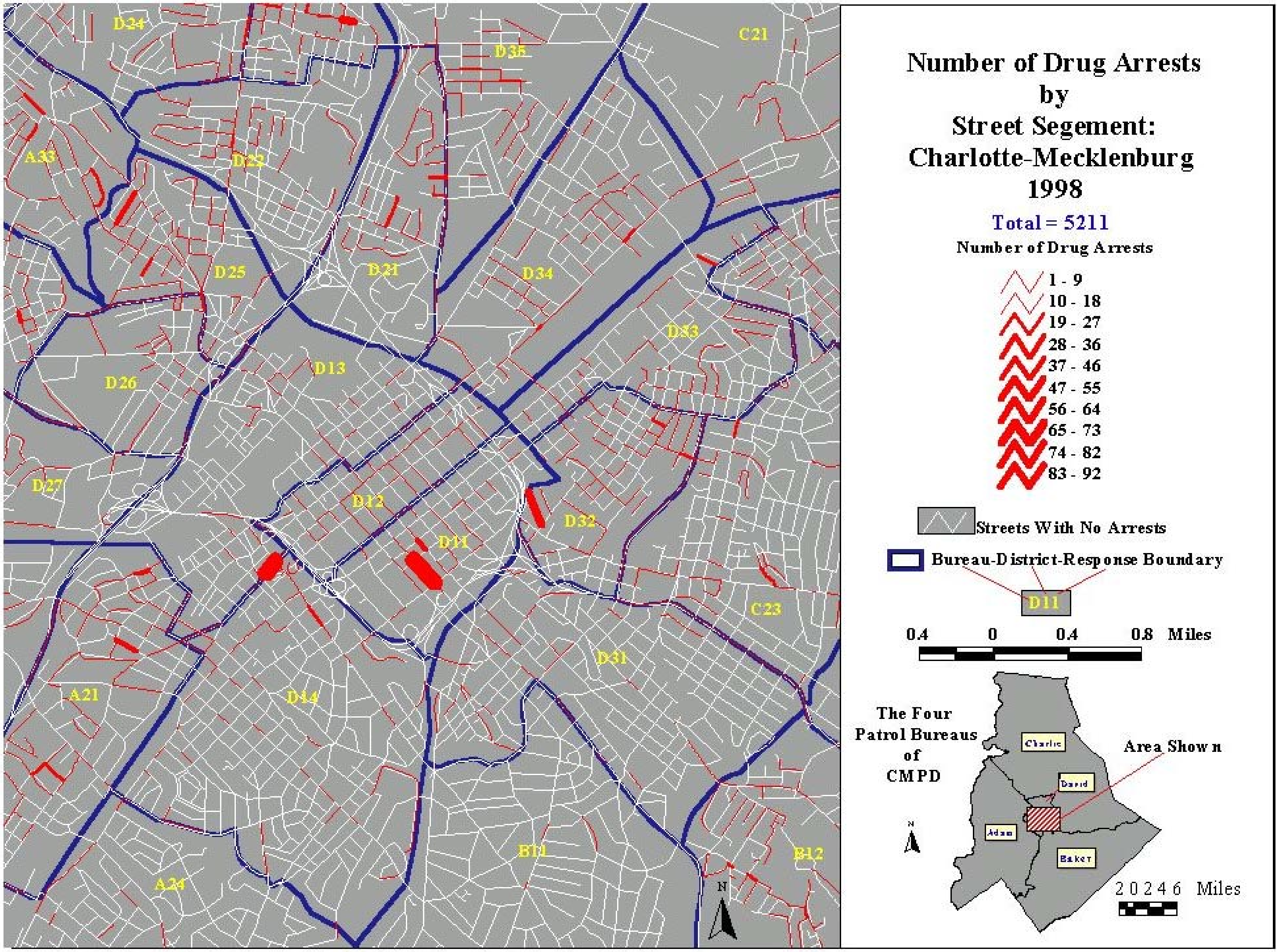

Number of Drug Arrests
by
Street Segement:
Charlotte-Mecklenburg
1998
Total = 5211
Number of Drug Arrests
1 - 9
10 - 18
19 - 27
28 - 36
37 - 46
47 - 55
56 - 64
65 - 73
74 - 82
83 - 92
Streets With No Arrests
Bureau-District-Response Boundary
D11
0.4 0 0.4 0.8 Miles
The Four
Patrol Bureaus
of
CMPD
Area Shown
Charlie
David
Adam
Baker
2 0 2 4 6 Miles
N
D24
D35
C21
A33
D22
D25
D21
D34
D33
D26
D13
D27
D12
D11
D32
C23
A21
D14
D31
B11
B12
A24

Figure 6.0

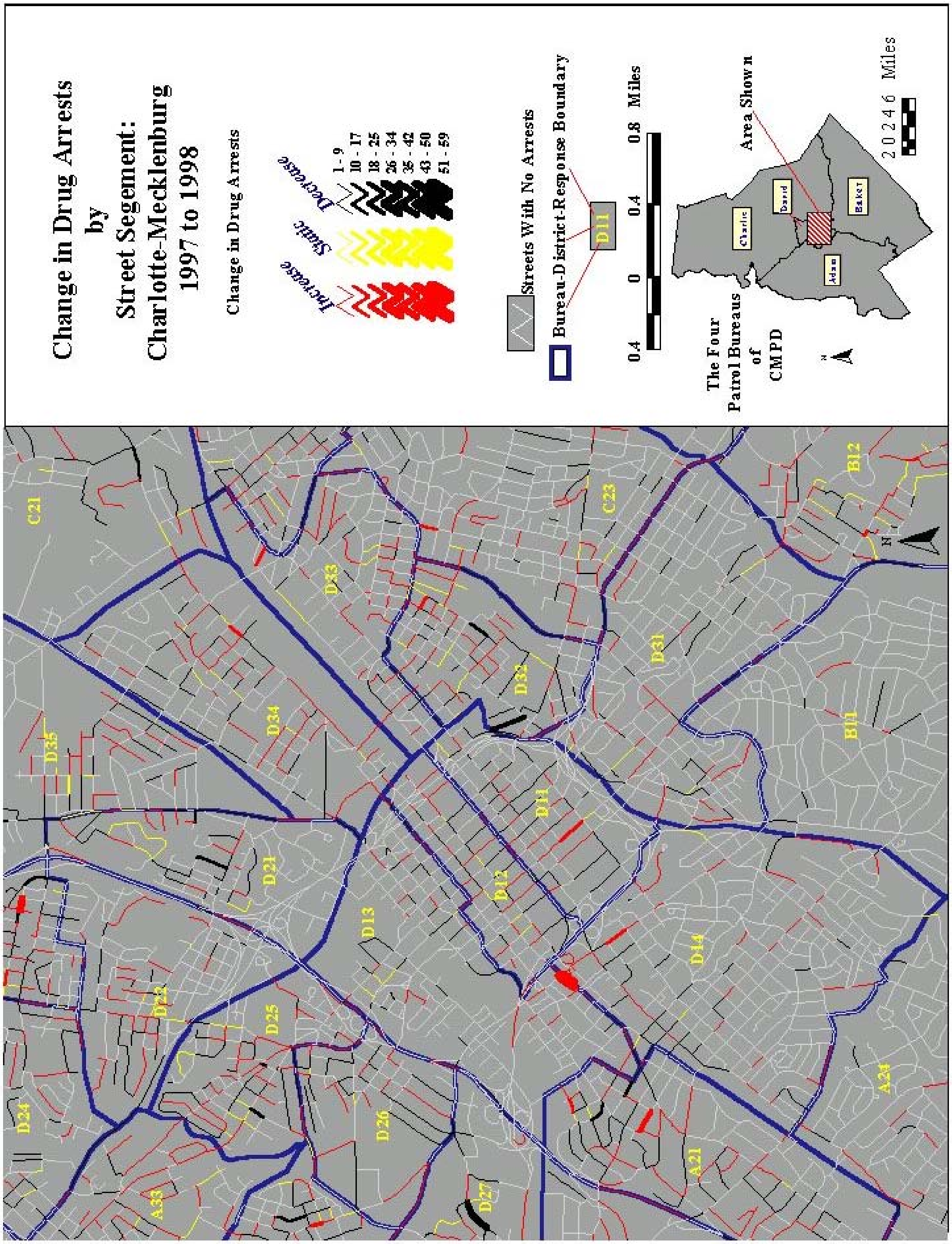


Figure 7.0

on this block accounted for a majority of the drug arrests. During 1997, there were 33 arrests. One motel accounted for 26 arrests, 2 were made at the other and the remaining were made at other places on the segment. The next year this segment generated 89 arrests with 67 and 20 emanating from the two motels. Obviously, the types of places on this segment and their management were attractive to drug trade businesspersons and their clients.

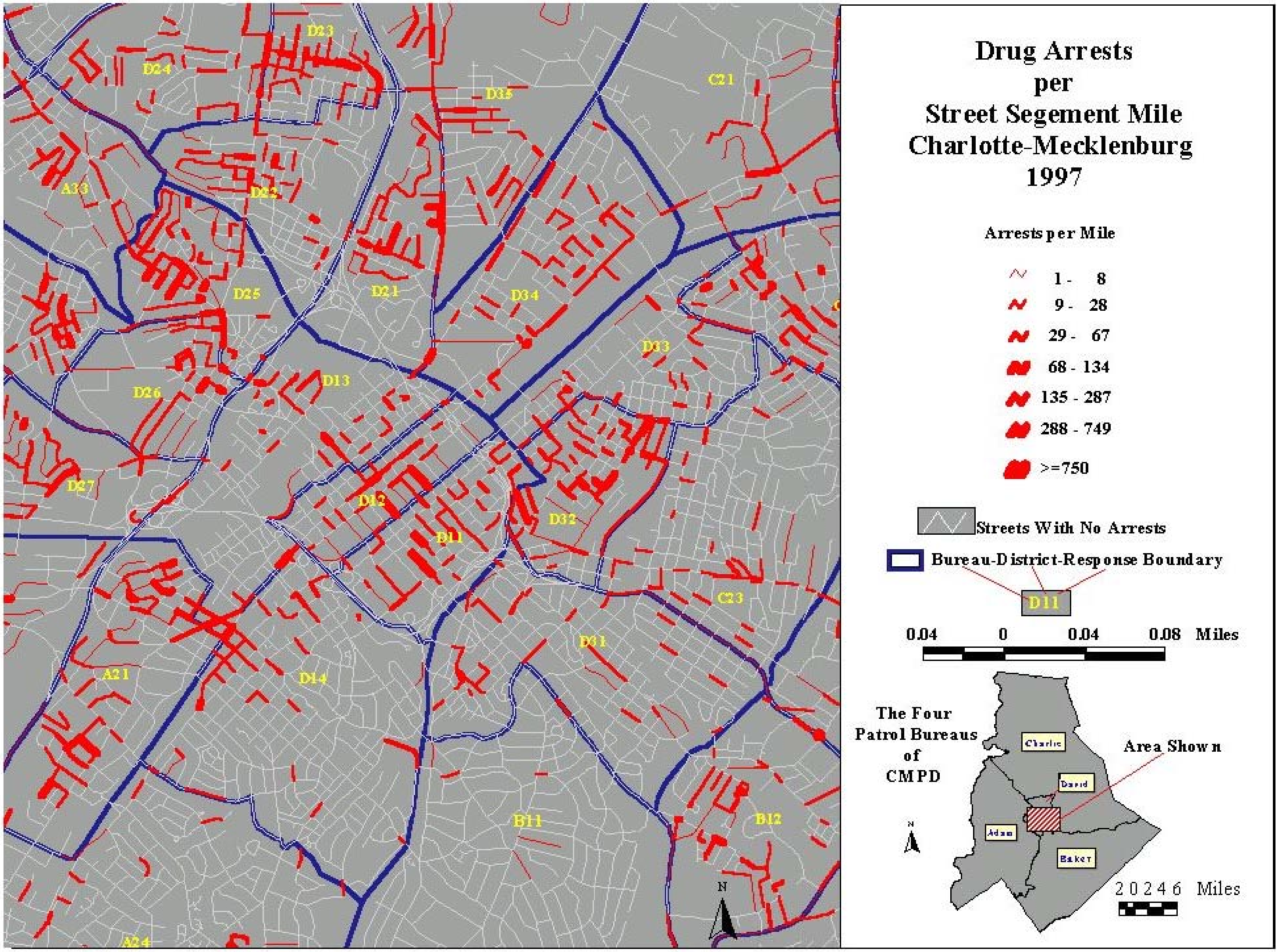
Across Figure 7.0 one can observe other BDRs with segments experiencing extreme increases in drug arrests (e.g, A21) and others showing extreme decreases (e.,g D27). Still, it is important to observe how interconnected streets can have segments alternating with increases, decreases, and static arrests. For example, returning to BDR D32 in the southwest corner, there is subnet of segments showing decreases. Directly northeast there is another subnet of segments most of which experienced arrest increases; and further northeast is another subnet of segments with a mixture of arrest activities. The point is this BDR is heavy with drug activities and the mixture of street segments in such a small space with different arrest activities implies there might be displacement-taking place. An increase of police activities (i.e., arrests) on some segments may move drug activities to other streets. However, this notion of displacement infers that the problem may disappear from one place and pop-up in another. What is occurring in BDR D32 may not be displacement but drug activity circulation. Circulation whereby a specific segment may oscillate through three time periods going from high activities –to low activity- and then back to high activity

These discussions have pertained to expressing the frequencies or counts of intoxicated pedestrians or drug arrests by street segment. Another mode for viewing and analyzing crime and calls for service is to express the variable in a ratio unit which standardizes interpretation. The following discussions reexamine drug arrests between 1997 and 1998. This time, instead of using counts or frequencies of arrests for each segment, the new metric will be the number of drug arrests per street segment mile. This metric controls for the differential length of street segments, but does not incorporate street types and widths.

The procedure for calculating this new variable or attribute is very straight-forward. First, in the street file, the user needs to be certain that the segment *length* is in the desirable measure (miles or kilometers). After the number of arrests have been determined for each segment, the attribute table is put into edit mode and a new field is created. The new field will be arrests/mile(kilometers) and is simply the number of arrests divided by the segment length.

During 1997, the 5,056 drug arrests across Charlotte-Mecklenburg's 3,990.74 miles of streets yields an average of 1.53 arrests per mile. This number increased to 1.6 during 1998, with its 5,211 drug arrests. However, out of Charlotte-Mecklenburg's 34,463 street segments, only 2,056 and 2,158 during 1997 and 1998 respectively experienced drugs arrests. Despite the increase in segments and arrests between the years, the number of arrests/mile remained fairly static at 25.64 arrests/mile during 1997 and 25.61 during 1998.

Using this new measure creates a different map compared with the those showing only frequencies. Figure 8.0 depicts the drug arrests/mile during 1997. This measure accentuates the arrest activities. Most BDRs have many segments with a number of arrests per mile. For example, the boundary between D21 and D35 (Statesville Avenue) in the northern portion of Figure 8.0 reveals interconnected segments with high rates of arrests. Using the frequency counts only by segment obscured this problem (See Figure 8.0).


Drug Arrests
per
Street Segement Mile
Charlotte-Mecklenburg
1997
Arrests per Mile
1 - 8
9 - 28
29 - 67
68 - 134
135 - 287
288 - 749
>=750
Streets With No Arrests
Bureau-District-Response Boundary
D11
0.04 0 0.04 0.08 Miles
The Four
Patrol Bureaus
of
CMPD
Area Shown
Charlie
David
Adam
Baker
2 0 2 4 6 Miles
N
D23
D24
D35
C21
A33
D22
D25
D21
D34
D33
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D12
D32
D11
C23
D31
A21
D14
B11
B12
A24

Figure 8.0

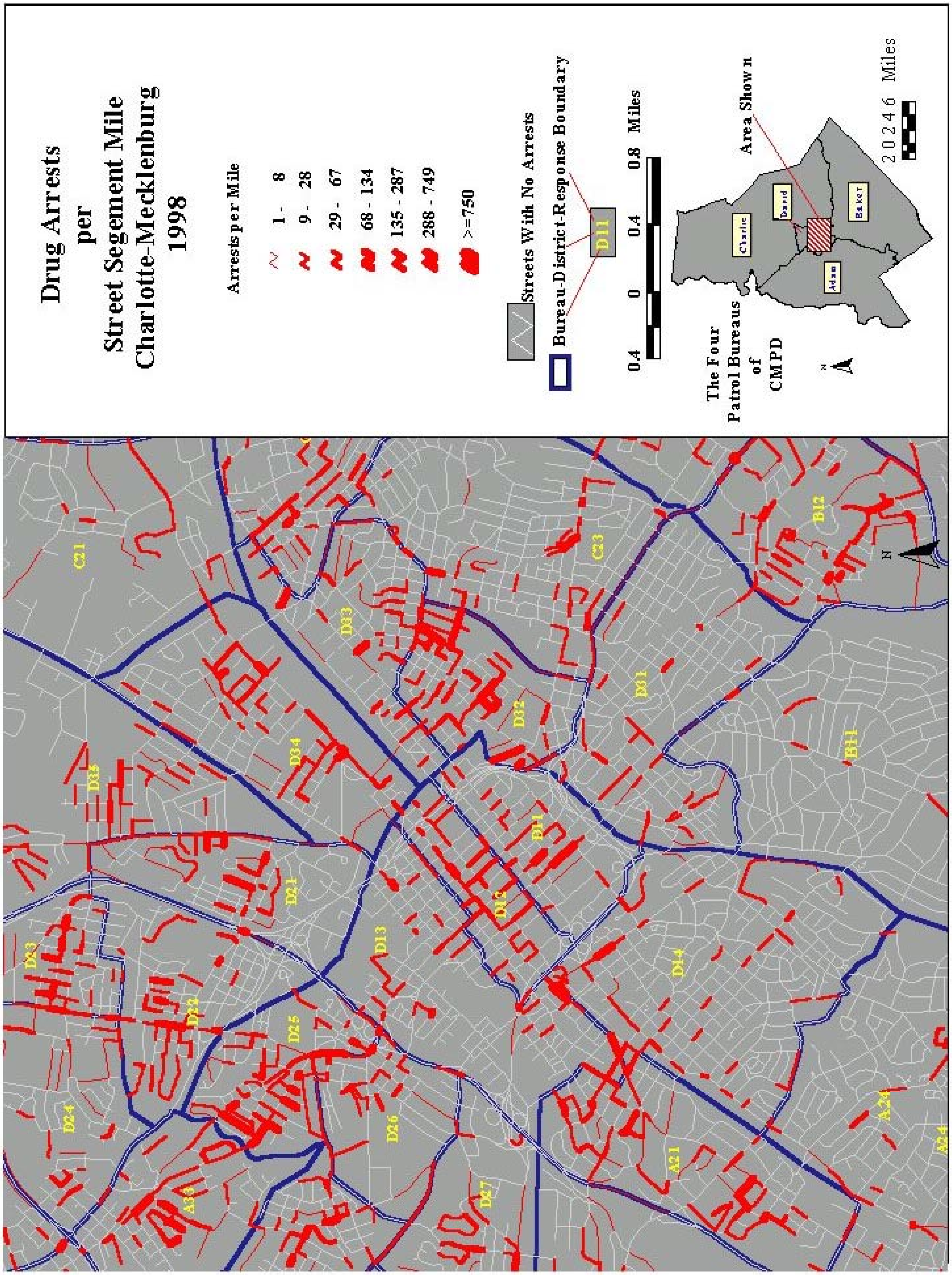


Figure 9.0

Figure 9.0 depicts drug arrests/mile during 1998. Like the previous figure, this one accentuates the drug arrest problems by street segment. This measure reveals a very large drug arrest corridor during 1998 that was easy to discern in Figure 6.0. This drug arrest area runs from BDR D13 northwest through D25 and A33.

A difference or change map using this measure is made just like the other difference maps in this discussion. The arrests/mile for 1997 are subtracted from the 1998 measure, thus producing Figure 10.

Just as the arrests/mile maps revealed problem areas that were not discernable in the frequency maps, the arrest/mile change map highlights problem segments and BDRs not as easily discerned from the frequency change map (Figure 7.0). For example, in the northern portion of D14, just south of the segment containing the two lower scale motels is the 600 block of East Morehead St. The were no arrests during 1997 in this segment, but during 1998 there were 11 suspects arrested at eight different times. All of them were effectuated at the same address or place. Only four of the suspects were residents or stayed at this place. This place is a former hotel that was taken over by the Public Housing Authority and converted into a 98 unit residential facility. The majority of the residents are older males. Other BDRs with segments exhibiting strong fluctuations in drug arrests per mile include B12 which is formally known as Grier Heights in the south-east; D32 the Piedmont Courts area; D21 & D23 in the north; D27 on the Westside of the map; and A21 in the southwest.

It is difficult, with both change maps, to assess the significance of change. In an operational sense, significant change can reflect a performance objective such as an increase of a particular percentage of drug arrests over a specified time period. Other interpretations of significant change may hinge on simple frequency changes – drugs arrest are up or down or the same. There are several statistical techniques or

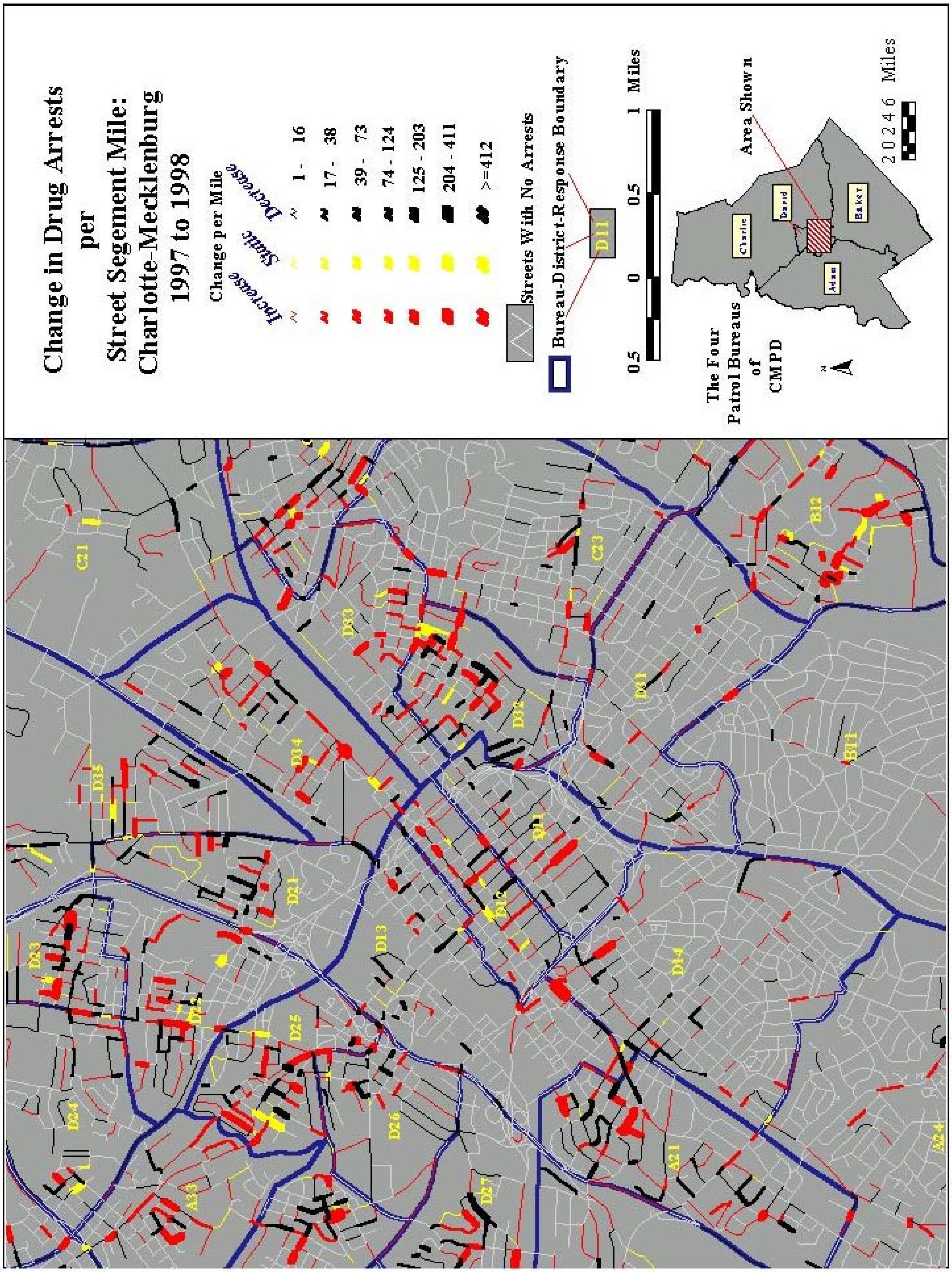


Figure 10.0

measures that can be used to assess the significance of change. The simplest one is to examine the standard deviation of change within the normal curve.

Figure 11.0 shows the standard deviational change of drug arrests per mile between 1997 and 1998. The average change was an increase of 1 drug arrest per mile. The standard deviation was 42 arrests per mile. The red graduated streets represents increases of drug arrests while the black represents decreases. Therefore, 1 standard deviation is an increase or decrease of 42 drug arrests/mile; 2 is 84; 3 is 128. Statistically, an increase or decrease of 2 or more standard deviations corresponds to the 95 percent of the area under the normal curve. Presumably, there is a 5% chance that the changes observed are random and not systematic. There is a major drawback with using the normal distribution. Often attributes or variables like those used in this study are not normally distributed, thus making it necessary to transform the data. Fortunately, this was not the case with Figure 11.0, but it was with many of the others.

Figure 11.0 is a map that seems to be less noisy than the other maps, so it is easier to detect significantly changing street segments. Segments beyond 2 standard deviations are considered significant change. Significant increases and decreases are revealed in BDRs B12, A21, D27, D25, D23, D21 and D32. Furthermore, the segments on S Tryon and E Morehead St in D14, previously discussed, register as being significant. This visualization technique allows one to examine the possible occurrence of displacement.

BDR David 27 (D27) located in the western portion of Figure 11.0 is highlighted in Figure 12.0. Segments of two major arterial streets are of importance in this illustration. W. Morehead Street, which is about .19 miles, is bordered on the north by commercial land use and on the south by light industrial use. Wilkinson Blvd, which .187 miles, is surrounded by commercial land use. According to the 1990 Census, 75% of the 2,120 people residing in the two-census block groups that comprise D27 are

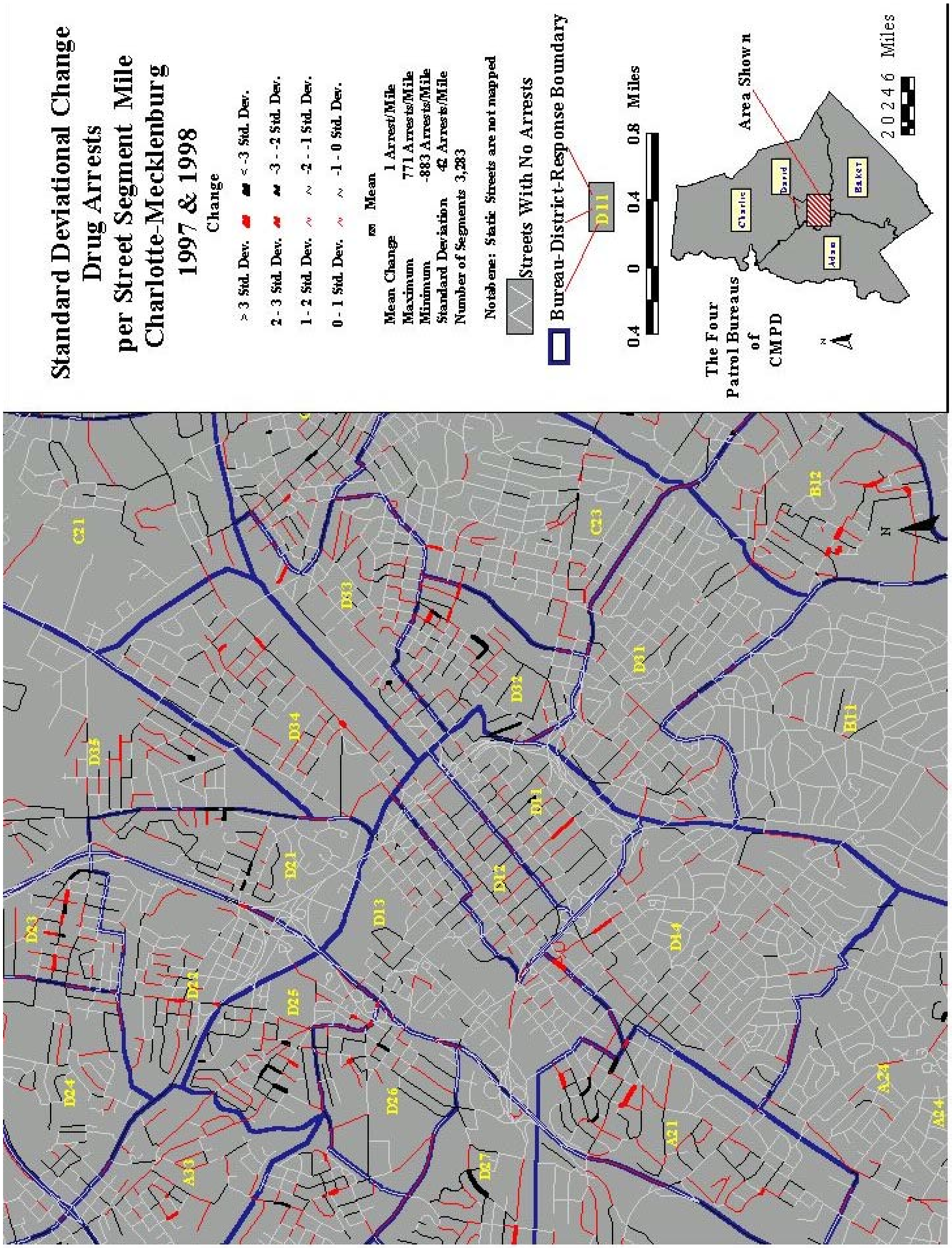
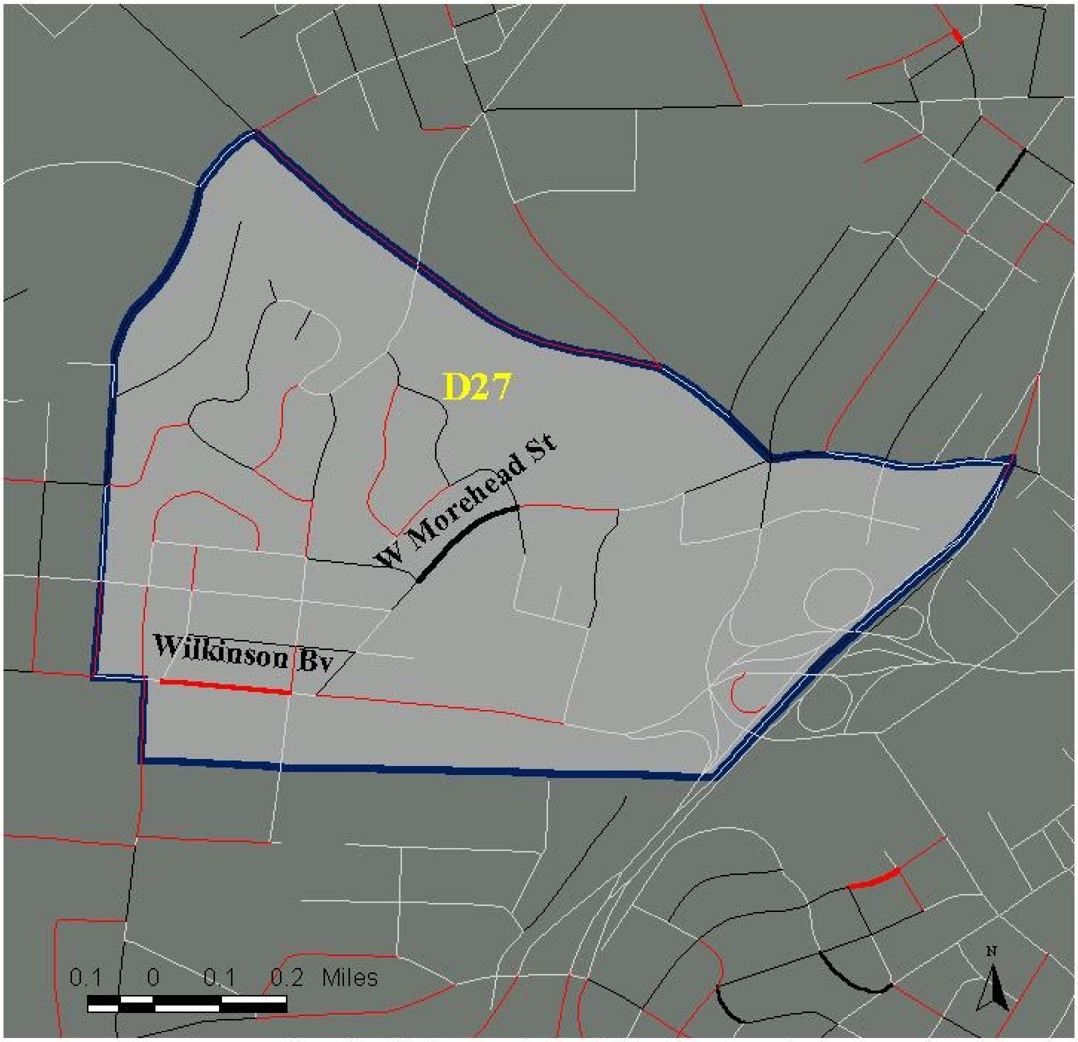


Figure 11.0

African American. The majority of the households are renters with over 142 Section 8 properties in D27. This area is located in an older part of the city. Wilkinson Blvd used to be the main artery on the city's westside, but it's prominence diminished over the years



David 27: Drug Arrest Displacement
W. Morehead St (1997) to Wilkinson Blvd (1998)

	W. Morehead St	Wilkinson Blvd
Arrests 1997	42	9
per Mile	223.4	47.15
Arrests 1998	5	42
per Mile	26.5	220.0
Arrests/Mi. Change	-197.0	173.0
Standard Deviation	-4.74	4.09

Change
Standard Deviation
< -3
-3 - -2
-2 - -1
-1 - 0
Mean
0 - 1
1 - 2
2 - 3
> 3

David 27

Streets Without Arrests

Figure 12.0

because of interstate highway development and more rapid growth in other parts of the city.

During 1997 and 1998, there were 120 and 102 drug arrests respectively in D27. Each year over a third of the arrests emanated from one of the two segments. During 1997, 42 arrests were made on W Morehead St and five during 1998. Wilkinson Blvd had the opposite experience with 9 during 1997 then 42 during 1998. A lower scale motel - boarding house on W. Morehead St accounted for 36 of the 42 arrests during 1997. Two similar types of places on Wilkinson Blvd accounted for 35 of the 42 arrests during 1998. The inference being made is that the arrests made on W. Morehead St displaced drug activities to similar types of venues or places on Wilkinson Blvd, thus this segment generated the larger number of arrests during 1998. Three of the people arrested on W. Morehead St during 1997 were arrested again on Wilkinson Blvd during 1998. The three factors of proximity, similarity of venues, and the same actors or suspects strongly point to displacement as the process creating this spatial pattern.

Conclusions

The *Safe Streets* technique provides an intermediate aggregation process between small point locations and large areal units. The new unit of analysis is the street segment, which is a valid and easily understood geographic feature. By aggregating crimes and calls for service to the street segment, it is easier to visualize and interpret maps instead of having to wade through a mass of dots or icons indicating events at a location. The point location information can be used in tandem with the street segments. This method, coupled with techniques in cartographic design, allows one to produce maps examining the changes in crime frequencies or crimes per mile per street segment between different time periods.

This technique provides flexibility for the user. Cartographically, graduating street color instead of size is another way for visualizing a problem. Statistically and analytically, the X,Y coordinates of the segment's midpoint can be extracted with a script and used as the unit of analysis for interpolation and other spatial analytic techniques.

There are many other applications for this technique including: using the street segment as the unit of analysis for crime maps or registered sex offender maps intended for public consumption and providing a visual record of the amount of officer time or departmental resources spent on special projects on a particular street segment. Moreover, this technique has been used in maps of robbery and burglary in Baltimore County, Maryland and drunk driving in Phoenix, Arizona. Informal reactions from crime analysts from both police departments have been very favorable. One crime analyst felt that the *Safe Streets* technique with the intersections would be excellent for describing, assessing, and analyzing traffic accident patterns.

Another major benefit of this technique is that it is simple to do. There are three essential components: ArcView, a street file, and an incident file. The fourth essential component would be an analyst with some cartographic skills.

Mapping Out Hazardous Space For Police Work

Introduction

Geographic information systems, automated mapping, and spatial analysis are becoming valuable tools for policing. These tools have been mainly employed in crime analysis and are functionally linked with police computer aided dispatch and records management systems. These systems routinely capture a wealth of data about the specifics of crimes and calls for service including precise information about location. This mass of data contains useful information for crime analysis, but from this information we can also find out about the details and locations of incidents or calls where police officers are injured, use force, request immediate help, and are dispatched to potentially dangerous situations. The commonality among these different types of incidents is that they are dangerous or hazardous situations. Combining these hazardous incidents and mapping out their geographic attributes allows one to visualize the spatial variation of hazardous incidents. The following is a discussion on using GIS and spatial models for delineating and visualizing hazardous spaces for police work. Two methods are discussed. The first examines the densities of hazardous incidents and creates a composite map of hazardous space. The second, is a Poisson probability based model that is used to assess risk rates for each of the different types of hazardous incidents.

The Density Model

Figure 13.0 depicts the *Spatial Organization of Charlotte Mecklenburg Patrol Operations.* The largest geographic unit for delivering patrol service is the Service Bureau for which there are four (Adam, Baker, Charlie, and David). Each Bureau is subdivided into three Service Districts (9 districts). Each District is further subdivided into Response Areas (Ninety-three in total). Finally, the Response Areas are subdivided into Reporting Areas of which there are 892 across the entire jurisdiction.

Table 1 lists the types of calls or incidents and their frequencies during 1997 that are used for delineating hazardous space. *The Emergency Calls* are considered hazardous for two reasons: first, the emergency designation implies a situation which is life threatening or in immediate danger of escalation; and second, multiple patrol units proceed to the call as fast as possible, hence increasing the probability of traffic accidents or other calamities. The 21,592 emergency calls constitute 5.18% of the 416,584 dispatched calls for service during 1997.

Armed Robberies and Gun Assaults are the next most frequent type of hazardous call. Obviously, weapon use merits the inclusion of this type of call into the scheme.

Uses of Force incidents are included in this scheme. These are officer reported use of force incidents (Table 1). It is standard policy for an officer to report when he/she has to use any type of force with a suspect. These data are not differentiated by severity, but range from pushing to wounding a suspect. Furthermore, these data did not emanate from an automated information system but had to be retrieved from paper reports.

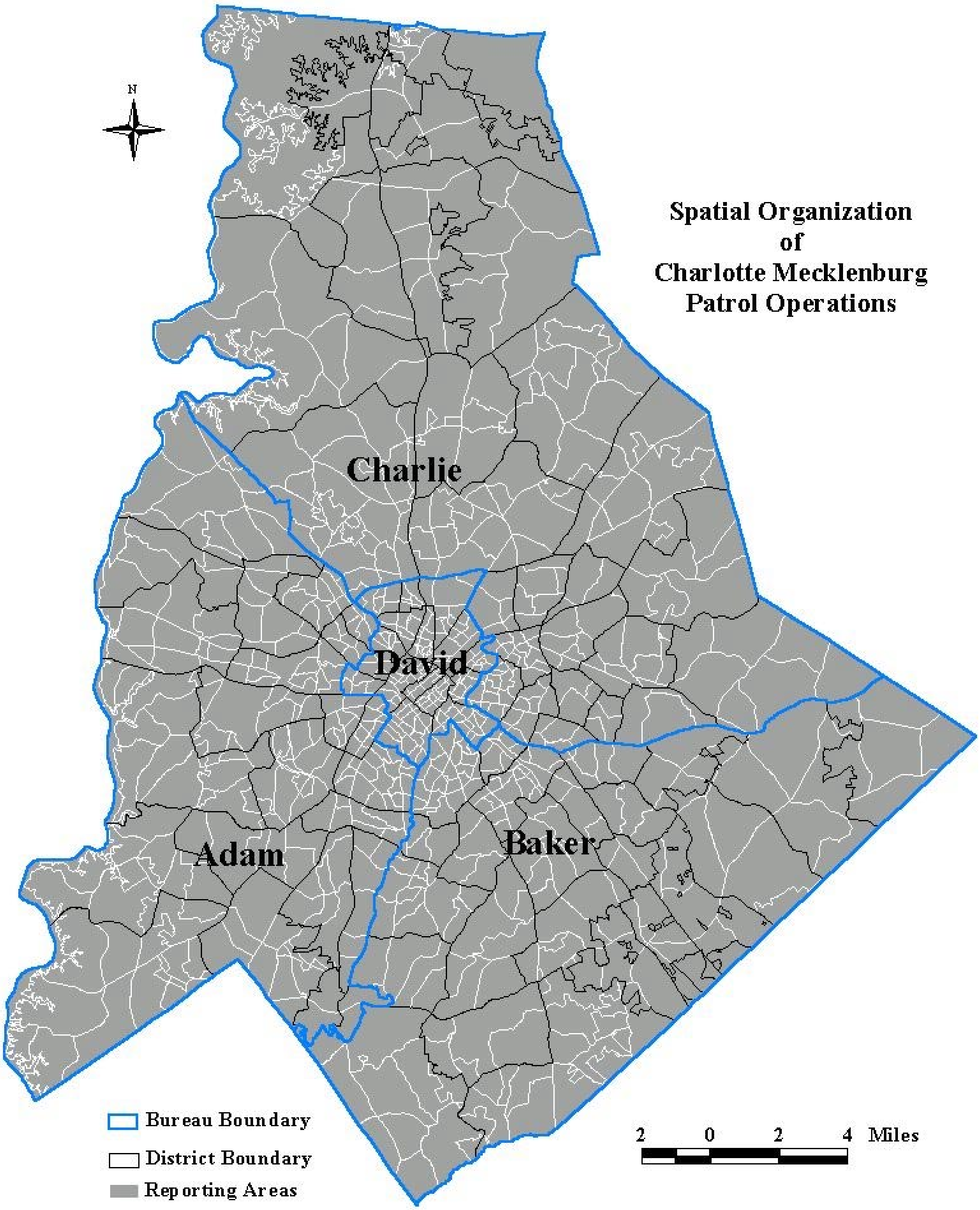

N
Spatial Organization
of
Charlotte Mecklenburg
Patrol Operations
Charlie
David
Adam
Baker
Bureau Boundary
District Boundary
Reporting Areas
2 0 2 4 Miles

Figure 13.0

Table 1: Hazardous Incidents & Calls 1997

Calls-Incident Types	Number
Emergency Calls For Service	21,592
Armed Robberies and Gun Assaults	3,523
Use of Force Incidents	410
Injuries to Officers	245
Help Me Quick Calls	44

Injuries to Officers is another type of hazardous incident or call that had to be retrieved from paper reports. These data include all injuries to sworn police officers in the field. Eliminated from these data are injuries received during training and injuries to civilians and officers in an office setting. Like the *Use of Force*, the injury data are not differentiated by severity.

The last type of call is the least frequent, but in many respects is the most hazardous. The *Help Me Quick Call* is one where an officer is in the field and becomes involved in a situation where he or she requires immediate assistance or backup. As revealed in Table 1 there were 44 such incidents during 1997. This type of call generates a rapid response from numerous patrol units. During 1997, a total of 245 patrol units responded to the 44 calls. This is an average of 5.5 units per call with a maximum of 35 patrol units responding to one call.

Procedures

Three interrelated pieces of software are used for this analysis. ESRI's ArcView GIS software and its Spatial Analyst extension are used for managing and analyzing data and producing maps.[1] The Crimestat's nearest neighbor analysis routine is the third piece of software (Levine, 1999).

The rationales and justifications will be discussed later, but there are seven basic steps in the analysis: 1) the point coordinates for the street block addresses of the incidents/calls are acquired through address matching; 2) using Spatial Analyst a ½ mile grid coverage is constructed for Charlotte-Mecklenburg ; 3) five grids are constructed measuring the density of the specific types of calls or incidents per square mile; 4) frequency histograms of the grid densities are constructed for each incident/call; 5) extreme significant thresholds levels for each density grid are selected from inspecting the histograms and descriptive statistics; 6) new threshold integer maps are constructed with grids meeting or exceeding the thresholds determined in step 5 receiving a score of 1 while other grids set to 0; and 7) the five threshold maps are added together with grids recording a score of 5 being the most hazardous.

The rationale and justification for the ½ mile grids is a bit involved. There are numerous rationales or rules of thumbs for selecting the grid size and a search radius for smoothing the data if one were to use kernel methods (See, Williamson, D., et al, 1999). The purpose of this analysis is to show the spatial co-variation of five phenomena, but the spatial properties for each vary greatly. This conclusion was reached after examining the average first, fifth, and tenth order nearest neighbor statistics for each incident or call type (Table 2) (See, Bailey and Gatrell, 1995: pp. 88-90; and Levine, 1999; pp. 137-142). The average nearest neighbor distances are too dissimilar, so as an alternative a ½ mile grid cell size and search radius are used because a ½ mile (2640 feet) is about the

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[1] Environmental Systems Research Incorporated (ESRI) is based in Redlands, California, and developed ArcView and its Spatial Analyst extension.

average first order nearest neighbor distance between and among the centroids of the 892 reporting areas.[2] This procedure produced a grid of 4118 cells.

Table 2: 1997 Average First, Fifth, and Tenth Order Nearest Neighbor Distance of Hazardous Calls-Incident Types

Calls-Incident Types	First Order (Feet)	Fifth Order (Feet)	Tenth Order (Feet)
Emergency Calls	123.33	463.81	765.38
Armed Robberies and Gun Assaults	373.45	1128.49	1775.10
Use of Force	5300.99	8558.59	10060.07
Injuries to Officers	2350.80	6620.89	9164.36
Help Me Quick	5832.92	15228.57	21640.33

Most researchers have found crime density grid data rarely conform to a normal distribution, so in order to identify thresholds for each type of incident or call it was necessary to inspect descriptive statistics and histograms of the grid cell density distributions (See, Olligschlaeger, 1997). Initially, three standard deviations above the mean served as a rough guideline for a threshold, the histograms revealed values that were close to three standard deviations, but the proportion of the total grid cells containing threshold values ranged from 2.9% *(Help Me Quick)* to 4.6% (*Emergency Calls*) (Table 3). Therefore, the selected thresholds for each call constitute less than 5.0% of the total grid cells (Table 3).

Two judgment calls are made for this analysis. The first is that all grid cells recording a *Help Me Quick* call density greater than zero are included. The low frequency of this call, but its extreme severity requires that all incidents are included in

[2] The average first order nearest neighbor distance of the five hazardous incidents is 2,796.2 feet.

delineating hazardous areas. The second pertains to the issue of the intercorrelation between and among the different incidents and calls. The fact of the matter is that there is significant intercorrelation, but including the redundant information weights the grid cell. A *Help Quick Me Call* is an emergency; it can involve an armed robbery or gun assault, injuries to officers, or the use of force.

Table 3: Thresholds For Hazardous Incidents & Calls 1997

Incident & Call Types	Threshold/ Sq.Mi.	N Grid Cells	% of Total Cells
Emergency Calls For Service	> 145.89	193	4.60
Armed Robberies and Gun Assaults	> 27.82	189	4.58
Use of Force Incidents	> 3.77	162	3.93
Injuries to Officers	> 2.34	159	3.86
Help Me Quick Calls	> 0.00	123	2.90

Finally, another caveat that needs to be mentioned is that this analysis is focused on defining hazardous space by identifying the spatial co-occurrence of high densities of the five incident-call types. Thus, risk rates are not assessed or produced in this analysis.

Results

Figure 14.1 shows the *Emergency Calls/Sq. Mile* during 1997. The highest emergency call densities are mainly confined to the central portion of the map within the David Patrol Bureau (compare Figures 13.0 and 14.1). This patrol bureau has the greatest opportunities for generating large volumes of emergency calls because the Central Business District is a majority of the bureau. This area is the focus or hub of a majority of the daily commuting activity for work, business, and entertainment. Moreover, this patrol bureau contains a mixture of different land uses (e.g, commercial, industrial, and residential) which present additional opportunities for emergency calls. Finally, many of the residential neighborhoods within this bureau are lower income, public housing settings. These are settings that are both attractors and generators of crime, and emergency calls (See, Brantingham and Brantingham, 1995).

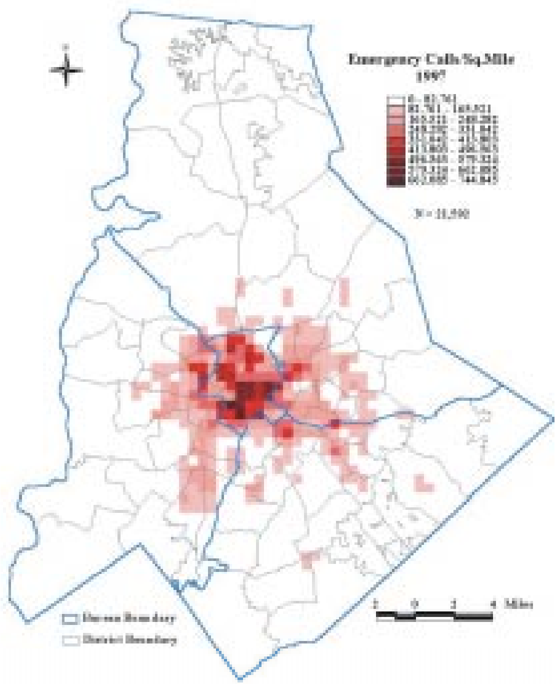

Figure 14.1

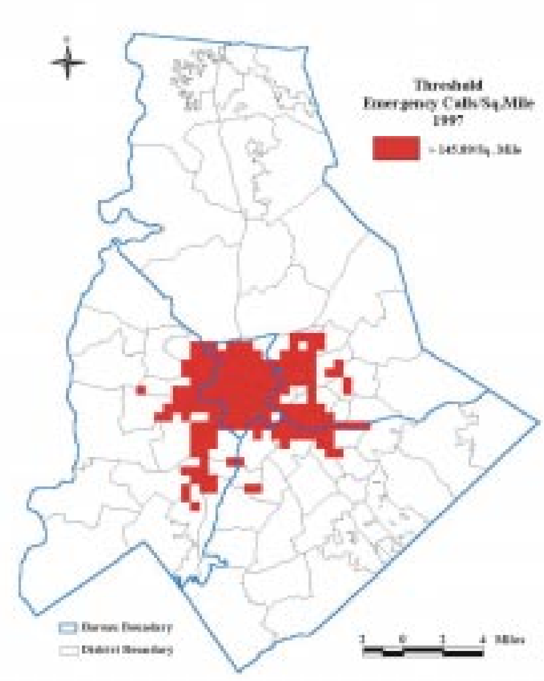

Figure 14.2

Figure 14.2 depicts the grids which exceed the threshold value. The majority of the grids in the David Bureau exceed the threshold limit.

Figure 15.1 is *Armed Robberies & Gun Assaults/Sq. Mile 1997.* The spatial pattern of these incidents is similar to the emergency calls (compare Figures 14.1 and 15.1). The David Bureau has a majority of high density grids, but other high density grids in other bureaus are adjacent to the David Bureau boundaries. The threshold map confirms the contiguity of high density armed robbery and gun assault grids to the David boundary, but also reveals an areal extension of the grids to the east and west of the David Bureau and a linear extension of the high density grids in the southwest and the southeast (Figure 15.2).

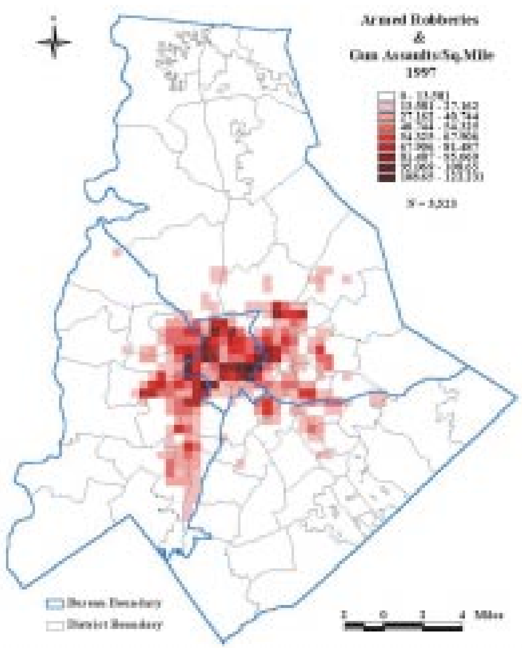

Figure 15.1

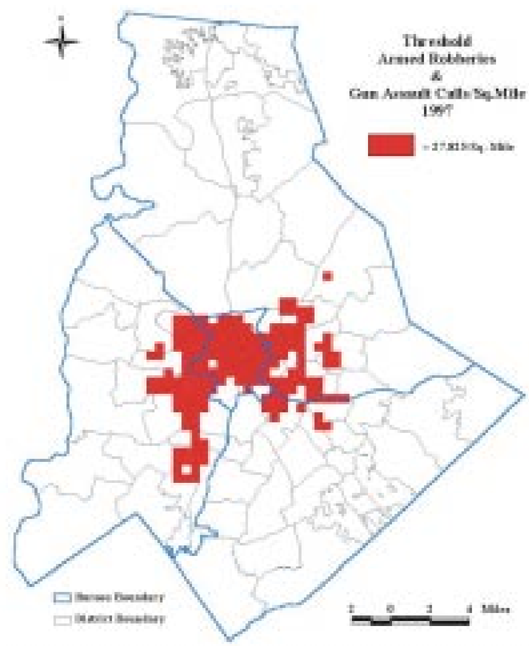

Figure 15.2

The *Use of Force/Sq. Mile 1997* is shown in Figure 16.1 The areal extent of the use of force is much less than the emergency or armed robbery calls (compare Figures 14.1, 15.1, 16.1). Still the highest density grids are within the David Bureau in the central city. Within the David Bureau, there are two distinct regions. First in the central portion of the David Bureau, there are four high-density grids which are connected by a corridor of high density grids extending to the eastern boundary of the bureau. The second lies in the west and northwest portions of The David Bureau adjacent to high density *Use of Force* grids in the Adam Bureau. The former region encompasses the heart of the downtown and to its east are lower income public housing residential areas. The latter region incorporates similar residential neighborhoods but also has a large mix of commercial and industrial land use. The threshold map (Figure 16.2) indicates the threshold *Use of Force* grids are mainly contiguous. However, there is not the contiguous linear extension of grids in the southwest and the southeast. There are, however, isolated small clusters of grids or islands of the use of force in the outlying areas.

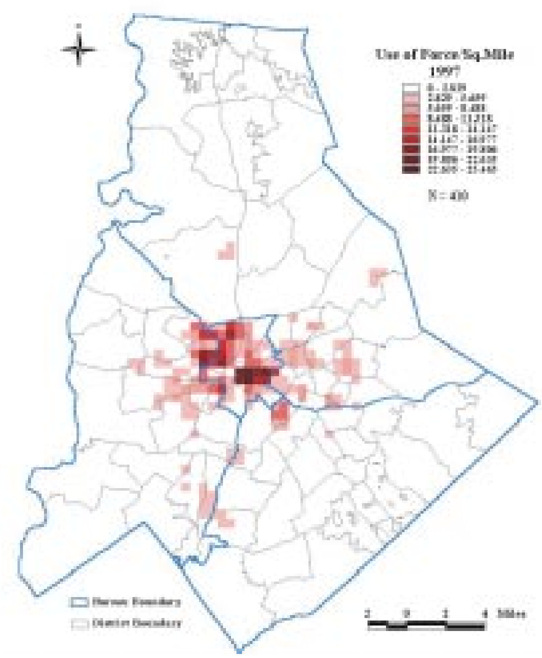

Figure 16.1

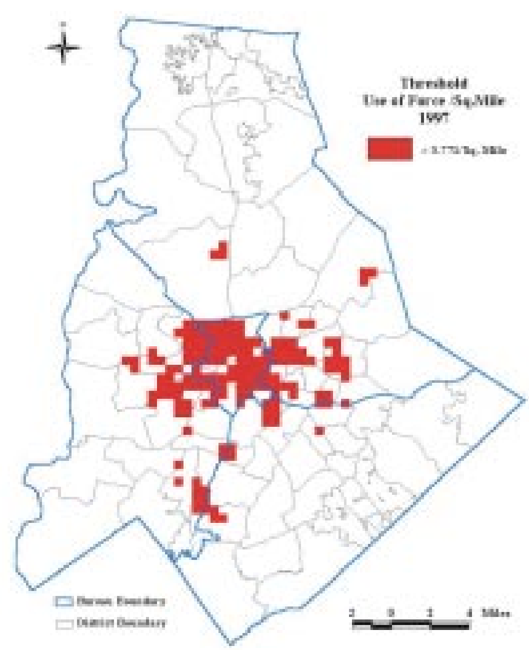

Figure 16.2

Figure 17.1 depicts *Injuries/Sq. Mile 1997.* The frequency of this type of incident is lower than the previously discussed incidents; hence the areal extent is less. The David Bureau contains the highest densities of officers' injuries. The injury patterns within the

David Bureau are similar to the use of force patterns. The threshold map (Figure 1 7.2) indicates that the David Bureau has the largest concentration of high-density injury grids. While there are isolated clusters or islands in the outlying areas, one can clearly discern three corridors or linear patterns of high injuries. The first is due east of the David Bureau in the Charlie Bureau. The second is due south of the first lying on the boundary between the Charlie and the Baker Bureaus. The third lies southwest of the David Bureau in the Adam Bureau.

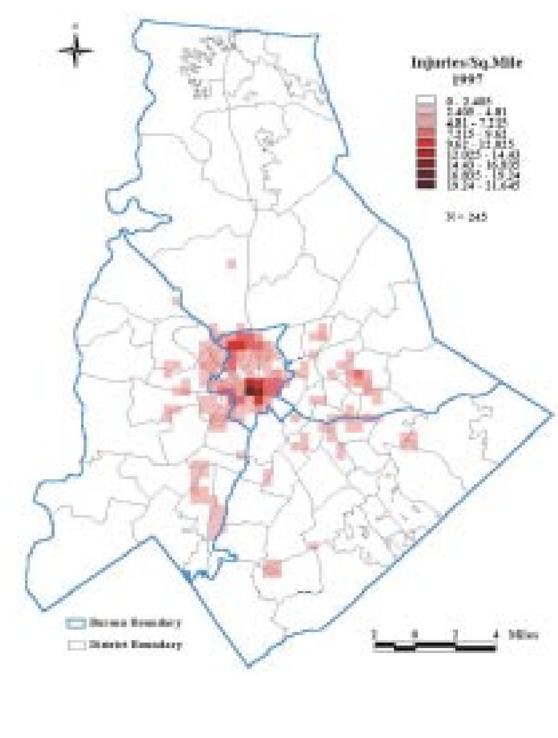

Figure 17.1

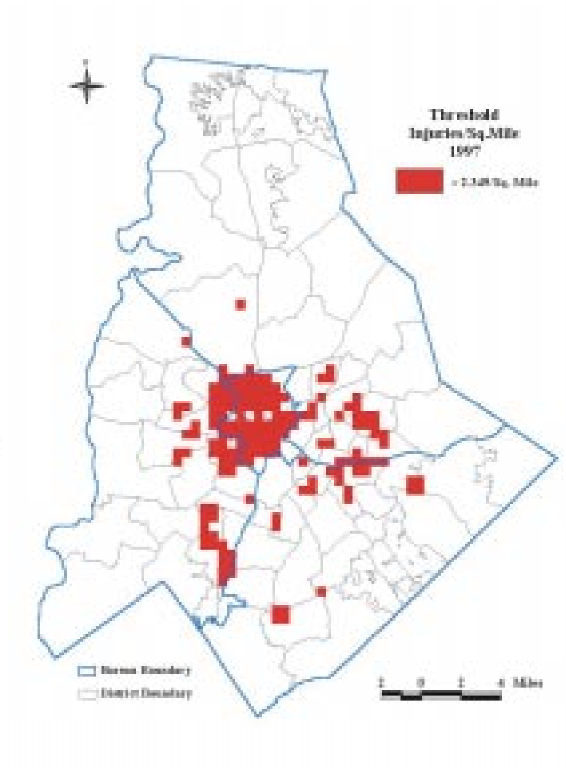

Figure 17.2

Figure 18.0 is *Help Me Quick (10-33) Calls/Sq. Mile 1997.* This map also serves as the threshold map since all of the *Help Me Quick* calls are used in this analysis. Like the other calls and incidents these have their highest concentrations in the central part of the city in the David Bureau. This would be expected, however, there are numerous grids or islands outside the central concentration recording a high density of calls. The paucity of *Help Me Quick* calls would make any generalizations about their spatial persistence short lived if one mapped out similar calls for other years. For example, during other years, there would still be the central concentration of calls but the locations of the outlying calls might vary from year-to-year or be spatially random. Nevertheless, as previously stated, the severity of these calls requires that they all are included in the delineation of hazardous space.

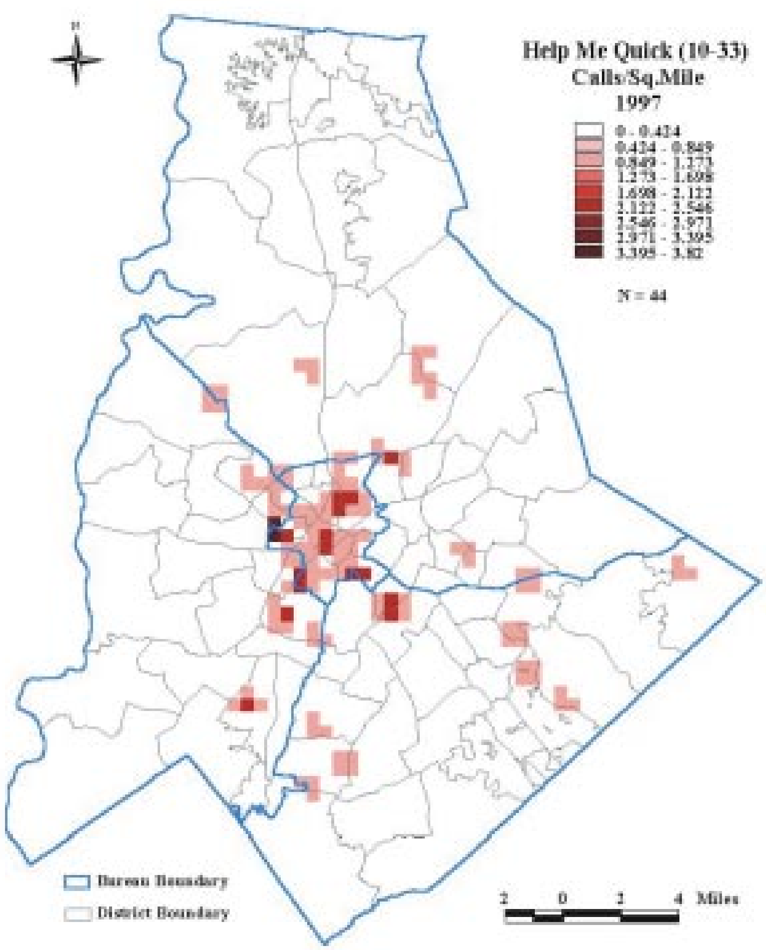

Figure 18.0

The sum of the five threshold maps is presented in Figure 19.0. Grids receiving a score of five are presented in red, thus having the highest density of all five hazardous calls or incidents. Only 39 grids or .95% of the total 4,118 grids record the highest hazard level (Table 4). Viewed another way, less than 8 % of the grids constituting Charlotte - Mecklenburg contain any level of hazard whatsoever.

Table 4 : Areal Extent of Hazard Levels 1997

Hazard Level	*N Grids*	*% of Total*
0	3793	92.11
1	109	2.65
2	69	1.68
3	54	1.31
4	54	1.31
5	39	0.95

The spatial pattern of the hazardous areas should not be a surprise given the review of the five threshold maps (Figure 19.0). The general impression of the geographic distribution of hazardous areas throughout Charlotte-Mecklenburg is that there is a distance decay effect. The greater the distance from the central part of the city and the David Bureau the lower the hazardousness. This effect is not uniform in all directions there is directional bias. For example, east and southeast of the David Bureau, there is a large contiguous mass of hazardous grids of varying levels. A similar pattern appears in the west and southwest. Conspicuously inactive or missing are hazardous grids immediately north and south of the David Bureau. An important question to be answered through examining similar data from several time periods is: are the outlying lower level hazardous areas likely to increase through time?

Figure 20.0 focuses on the Bureau-District-Response Areas in the David Bureau and the immediate neighbors in other Bureau-District-Response Areas. While the David

Bureau has a majority of the most hazardous areas, the Adam Bureau in the west has some as well. The most hazardous areas are laid out in two distinct regions. There is a southern region containing grids in D27,A22, A21, D14,D13,D12, D11, D31, D33 and B11 which contains the central business district, light and heavy commercial land use, and different types of residential neighborhoods, including many lower income public housing projects.

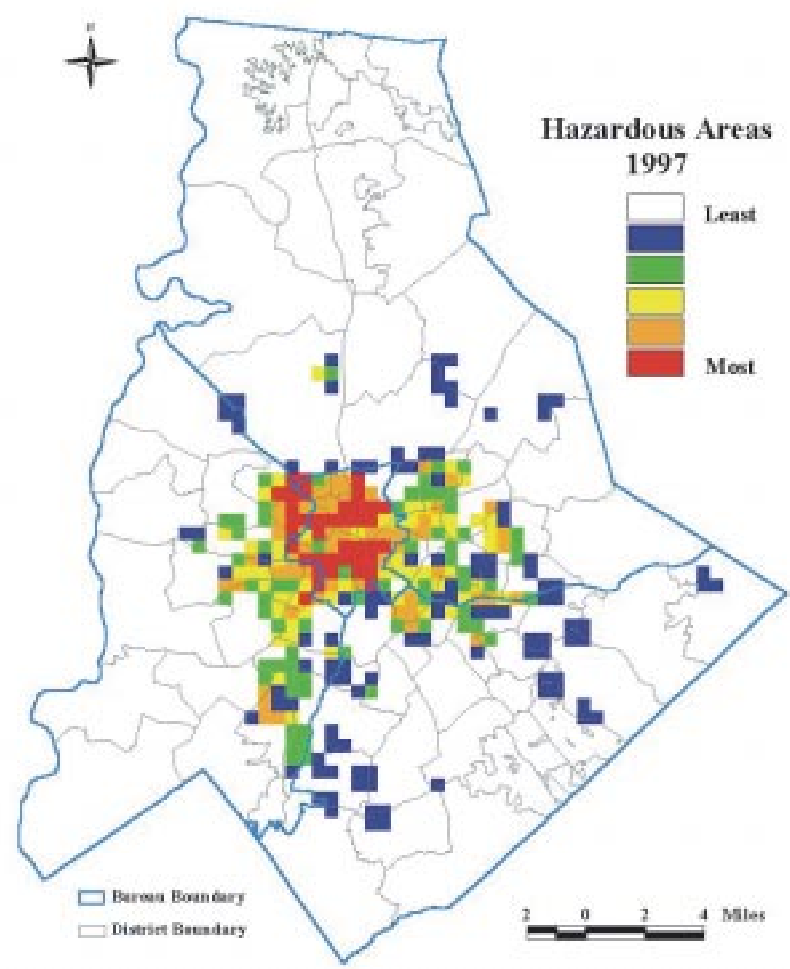

Figure 19.0

The northern region has grids in A35,A33, A32, D24, D25, D26, D22, D21, D34, D35 and corresponds with lower income residential areas situated among light and heavy industrial land uses with some light commercial and institutional land uses. The bridge between the regions is the most hazardous areas in D27. There is a clear buffer or transition zone of less hazardous areas between the two regions. Another important feature revealed in Figure 20.0 is how different bureaus, districts, and response areas share the same hazard levels along their common boundaries (e.g., D27 and A32). This is a graphic display of how problems are not confined to one geographical or, in this context, organizational unit.

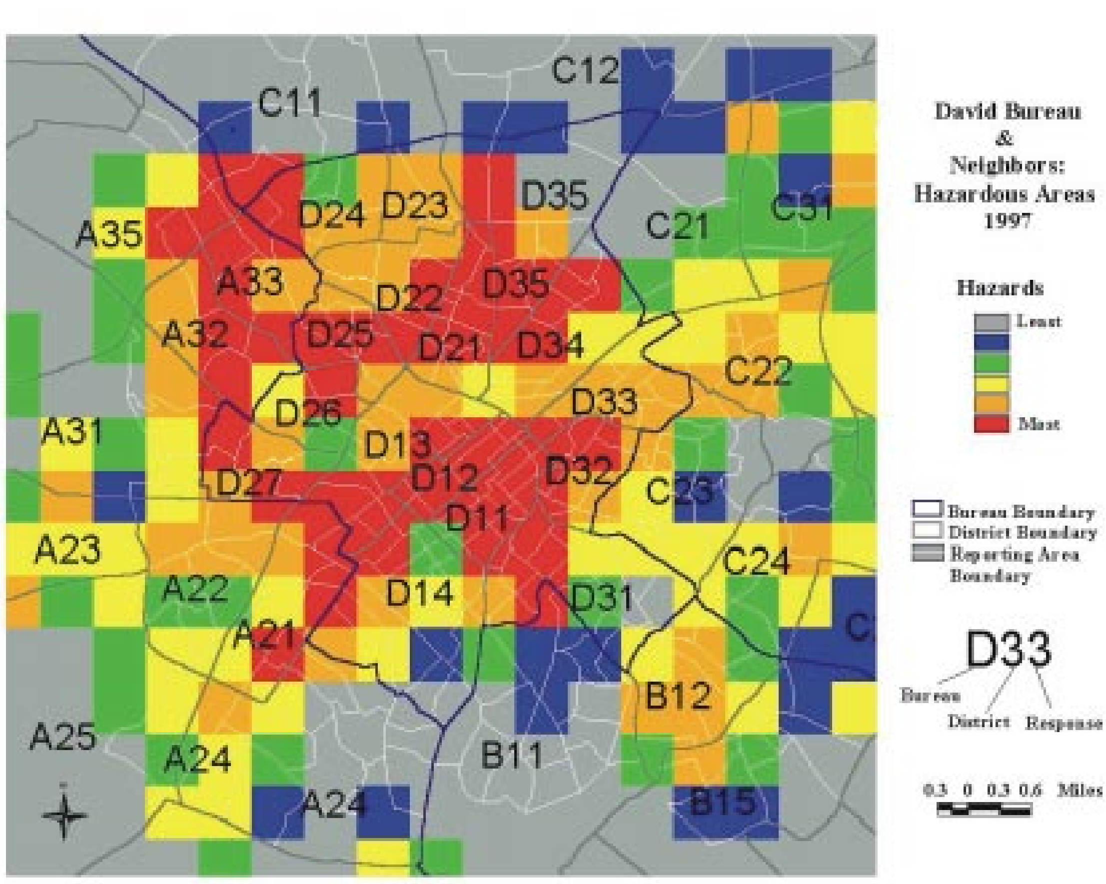

Figure 20.0

This procedure was repeated for 1998 with Figure 21.0 depicting the jurisdiction-wide distribution of hazardous areas. Comparing the two years

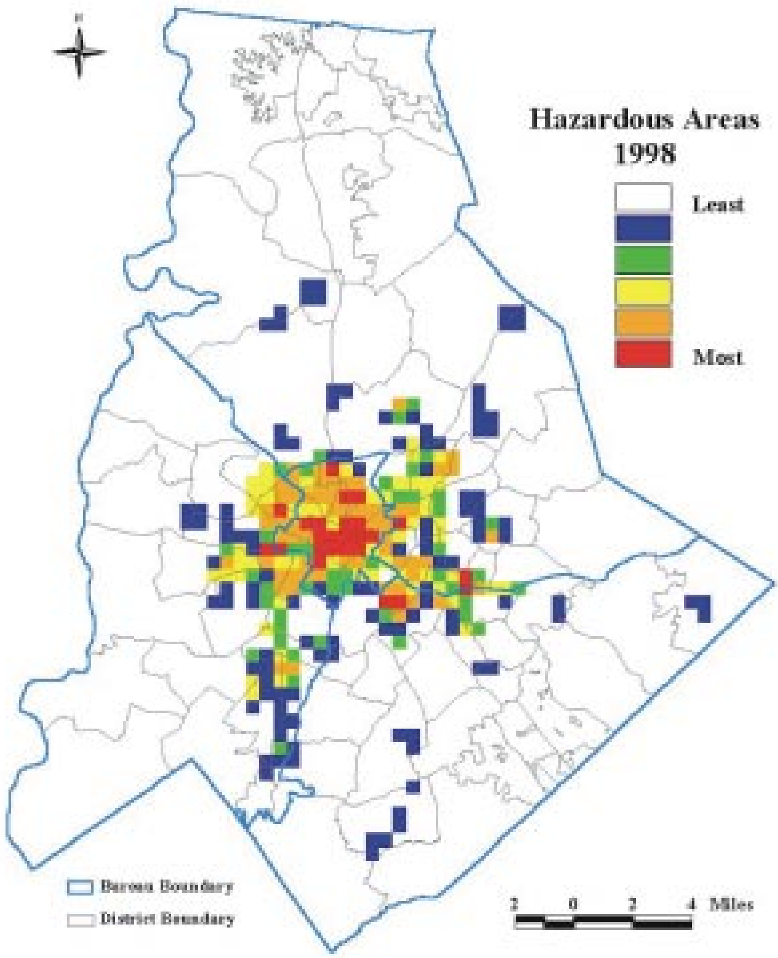

Figure 21.0

reveals a spatial change in hazardous areas (compare Figures 19.0 & 21.0). The David Bureau – Central City concentration of the most hazardous areas is not as pronounced during 1998 as it was in 1997. Furthermore, some new most hazardous areas emerge in the south central and southeastern portions of the city. While the number of most hazardous grids decreased between 1997 and 1998 (compare Tables 4 and 5) there remains a large contiguous block of most hazardous areas in the central city (Figure 22.1).

Table 5 : Areal Extent of Hazard Levels 1998

Hazard Level	*N Grids*	*% of Total*
0	3820	92.76
1	115	2.79
2	44	1.07
3	55	1.34
4	59	1.43
5	25	0.61

Comparing Figures 22.1 and 22.2 gives a better idea of the changes in hazardous areas in the central part of the city. The greatest difference between the two years is that the northern region of most hazardous areas very conspicuous during 1997 (Figure 22.2) is no longer visible because a majority of the grids yield lower hazard levels during 1998 (Figure 22.1).

The large southern region of most hazardous grids during 1997 had its spatial configuration change during 1998 (compare Figures 22.2 and 22.2). In general, this region contracted from the west, southwest and south, but expanded north by three most hazardous grids on a line running east to west from D26 to D33. Expansion occurred with most hazardous grids appearing in the east in C23 and in the southeast in B12. Finally, possible displacement has taken place. Examining the western portion of Figure 22.2 we see a corridor configuration of most hazardous areas emanating from D12 west to D27. During 1998, this corridor effect disappears (Figure 22.1). Two previously red

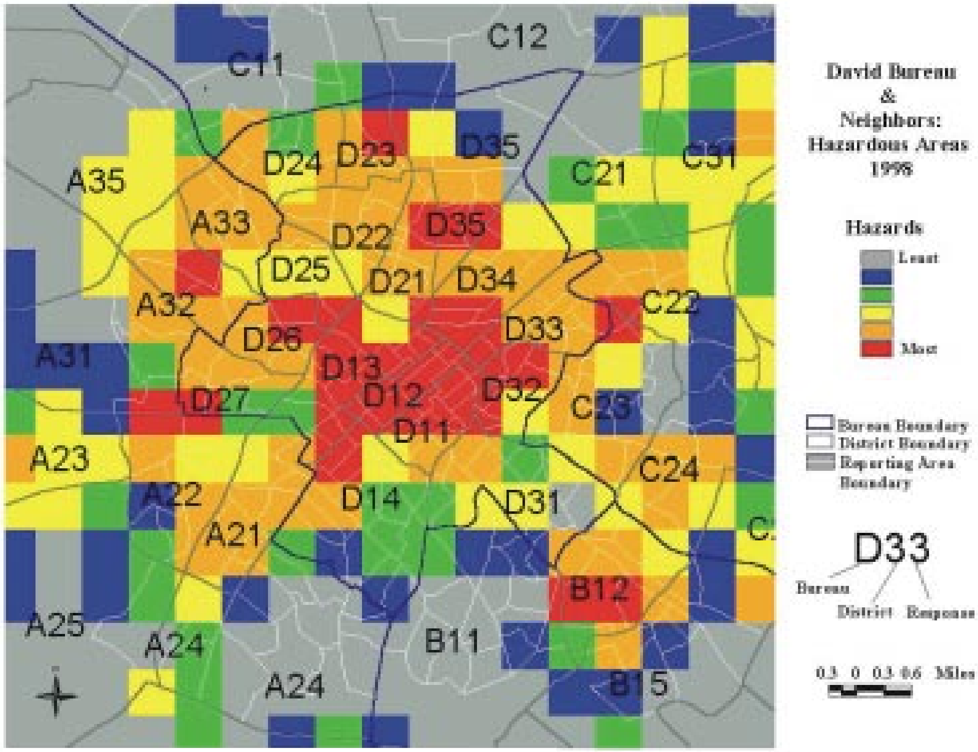

Figure 22.1: Hazardous Areas 1998

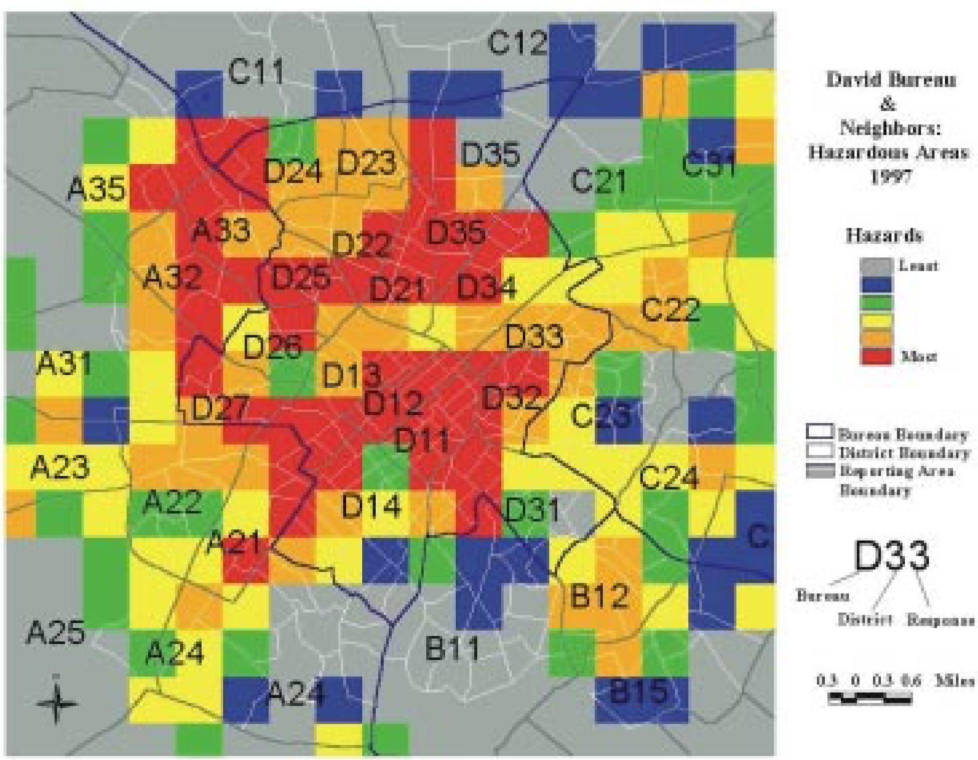

Figure 22.2: Hazardous Areas 1997

areas during 1997 decrease to green during 1998, but two most hazardous areas emerge in the west in areas previously yellow and orange. These maps imply that some sort displacement process may have taken place.

The hazardous space grids for 1997 and 1998 were added together to assess a two year level of hazardousness. According to Table 6, less than 10 percent of the grids in

Table 6: Areal Extent of Hazard Levels 1997 & 1998

Hazard Level	N Grids	% of Total
0	3725	90.45
1	144	3.49
2	36	0.87
3	26	0.63
4	30	0.72
5	32	0.77
6	21	0.50
7	34	0.82
8	32	0.77
9	25	0.60
10	13	0.31

Charlotte-Mecklenburg during 1997 and 1999 recorded any level of hazard. Moreover, only 13 grids or .31 percent of the total are the most hazardous. All of these grids appear in Figure 23.0 and are in the same portion of the jurisdiction that has been the major focus of this discussion. The David Bureau in the central business district and its immediate environs has the most hazardous areas for police work across the two years.

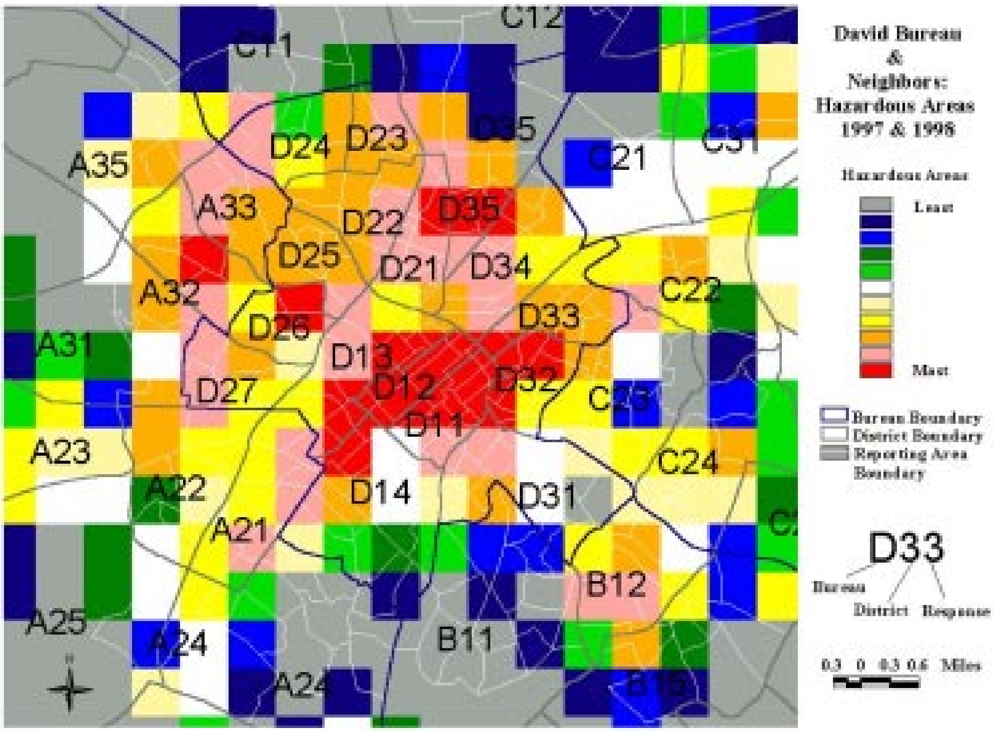

Figure 23.0

The efficacy of this methodology for predicting hazardous areas remains to be seen and obviously requires further testing. However, a recent news release on the Charlotte-Mecklenburg Police Department's web page conveys a story about two officers being fired upon by a suspect following a traffic stop. The location of this incident was at the intersection of Glenwood Dr and Tuckaseegee Rd (Figure 24.0). This intersection is located in a grid that recorded the highest level of hazard during 1997 and 1998.

Charlotte-Mecklenburg Police Department

CMPD News

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News Release

For Release 5/15/00

Suspect Opens Fire On Officers During Vehicle Stop

Two Charlotte-Mecklenburg Police Officers stopped a vehicle at 1:59 AM on Glenwood Dr. at Tuckaseegee Rd. that matched the description of a car used in two sexual assaults. The driver jumped from the car and opened fire on the officers with a shotgun. One blast from the shotgun struck the center of the patrol car?s windshield.

Sergeant Cam Selvey and Officer Jonathan Wolfe, both assigned to the David Two District, returned fire on the suspect who fled into some near-by woods. A police K-9 located the suspect who was uninjured. He was taken into custody without further incident.

Sgt. Selvey was struck in his hand by a shotgun pellet. He was taken to the hospital for treatment. Officer Wolfe was not injured.

The suspect?s identity is being temporarily withheld pending further investigation of the earlier reported sexual assaults.

Sgt. Selvey, hired 12/4/91, and Officer Wolfe, hired 7-24-91, are on administrative assignment while the shooting incident is being investigated.

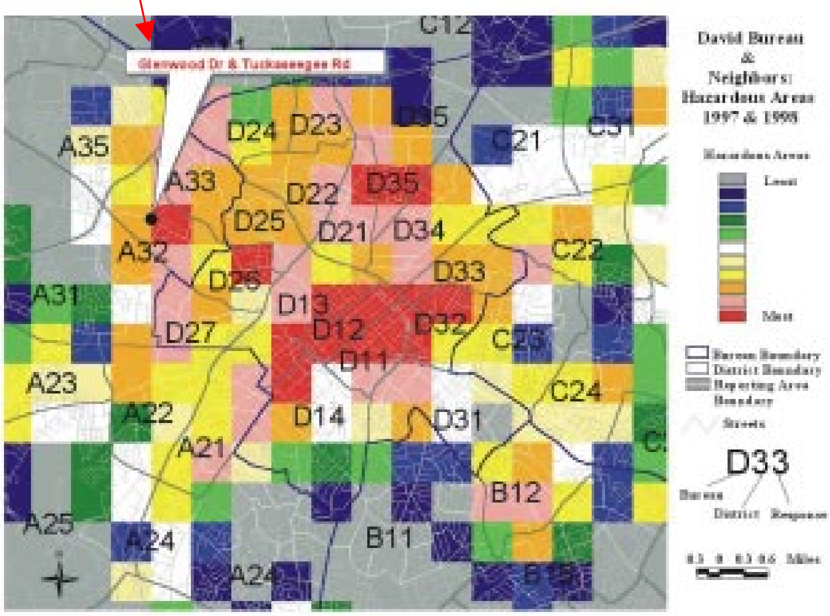


Figure 24.0

The Poisson Probability- SaTScan Model[3]

SaTScan is a spatial scanning model developed by the National Cancer Institute for the purpose of finding statistically significant clusters of cancer (See, Kulldorf, et al, 1997). This technique has been sparingly applied for assessing clusters of crimes (See, Jefferis, et al, 1998). This discussion is about applying SaTScan to four of the five hazardous incidents previously discussed for 1997 and 1998 for the purposes of assessing, analyzing, and visualizing high risk areas for each type of incident. The incidents not included are the *Help Me Quick* calls because of their low frequencies (Table 7).

Table 7: Hazardous Incidents & Calls 1997 & 1998

Calls-Incident Types	1997	1998
Emergency Calls For Service	21,592	24,064
Armed Robberies and Gun Assaults	3,523	3,190
Use of Force Incidents	410	426
Injuries to Officers	245	210
Help Me Quick Calls	44	42
Dispatched Calls For Service	416,584	426,601

Description of The Model

SaTScan examines rate based variables that are assumed to conform to a Poisson distribution across geographic areas. The null hypothesis is that rates of the variable are the same across all geographic units. An expected rate is calculated for all the geographic areas and then circular windows of varying size are projected over the centroids of the geographic units. For each window, the method tests the null hypothesis against the alternative hypothesis that the rate of the variable is higher within compared with outside the window (Kulldorff, et al, 1997: 162). Therefore, a log-likelihood ratio is calculated

[3] Software available from the National Cancer Institute at http://dcp.nci.nih.gov/BB/SaTScan.html

and maximized over the different clusters to indicate the most likely clusters. Statistical significance is acquired through multiple testing with Monte Carlo simulations (Kulldorff, 1997; and Kulldorff, et al, 1997). The model delineates a primary cluster of the variable in question and secondary clusters. The determination of the type of cluster is dependent upon the magnitude of the log likelihood ratio and the significance level.

The previously mentioned hazardous incidents for 1997 and 1998 are used in the SaTScan model. This model uses the 892 reporting areas for the geographic units of analysis. The denominator for the rates is the total number of calls for service recorded for each reporting area during 1997 and 1998.

Results

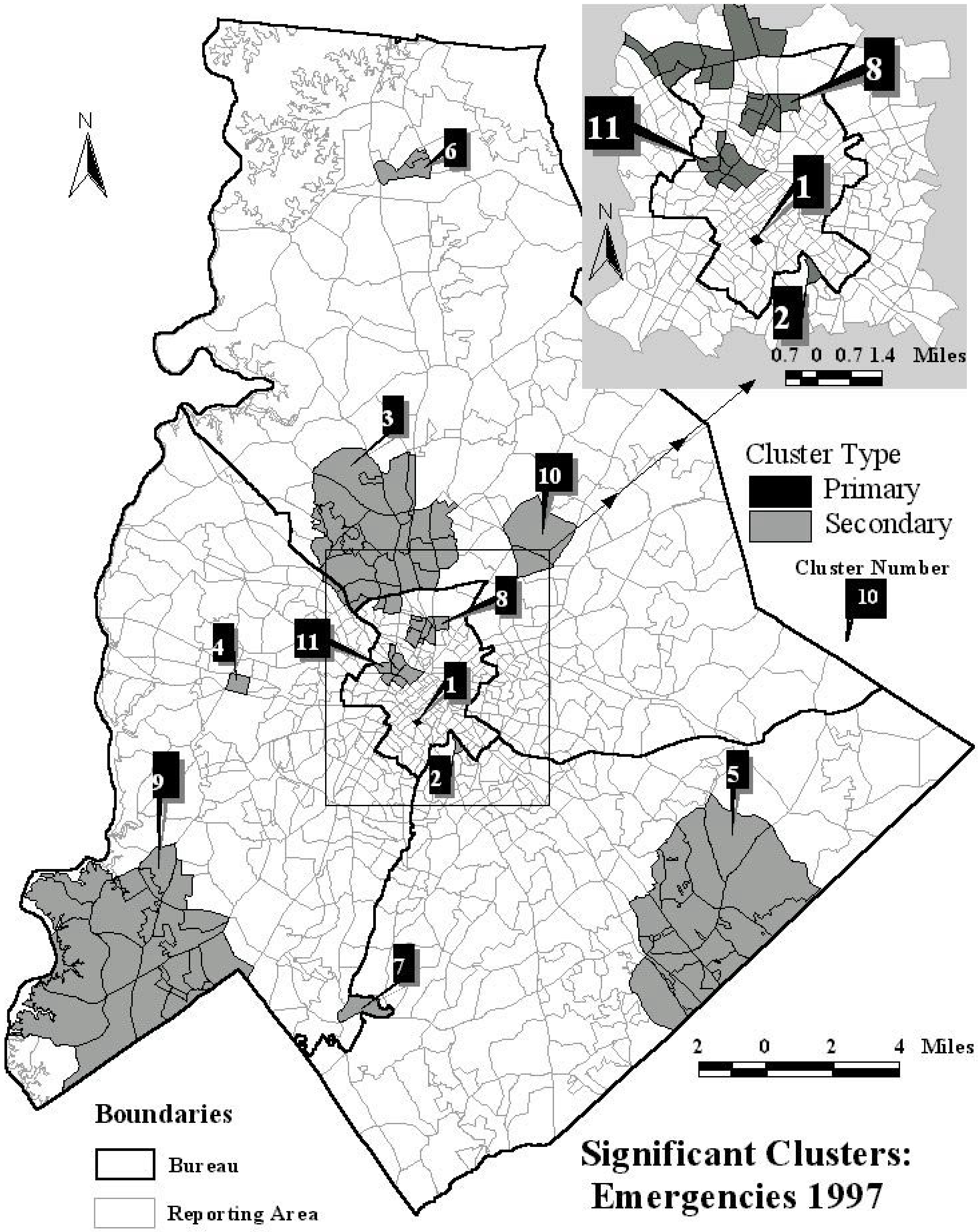
Emergency Calls For Service are the first incidents to be submitted to the SaTScan model. Table 8 presents the pertinent statistics for the two years. The first two columns are self-explanatory. *Cluster ID* is the number assigned to identify particular clusters. All primary clusters receive the ID of 1. *Type* is whether a cluster is primary or secondary. *N of Reporting Areas* is the number of reporting areas in the cluster. *Cases* is the frequency of the specific incident in the cluster. Cluster 1, the Primary cluster during 1997 which consisted of 1 reporting area, had 225 emergency calls where 25.24 were *Expected.* The *Relative Risk* for this cluster was 8.914 emergency calls per 1000 calls for service. The large magnitude of the *Log-Likelihood Ratio* and the *P-Value* indicate why during 1997 this was a primary cluster (Table 8). Moreover, only clusters significant at the .05 level are included in this analysis

As presented in Table 8, during 1997 there were 10 secondary clusters in addition to the primary cluster while 1998 produced nine secondary clusters. These clusters are mapped out in Figures 25.0 and 26.0.[4] At the onset one would review Figures 25.0, 26.0 and Table 8 and believe that single reporting area clusters must contain an overabundance of the factors that generate emergency calls for service. One could imagine many hot spots and repeat address calls for service in a small space. As a matter of fact, the primary clusters(1) during 1997 and 1998 have similar characteristics to secondary Clusters 2, 6, 7, and 10 during 1997 and 2, 3, and 8 during 1998. In other words, the same conditions creating the high emergency risk rates in the primary clusters are the same in the aforementioned secondary clusters. The majority of the emergency calls for service in these clusters are the same in nature. Moreover, the majority of emergency calls emanate from the same types of places all of which are repeat address generators of calls. This is because all these places generating emergency calls are funeral homes. The emergency designation, by policy, is given to requests from funeral homes for police escorts. Funeral escorts account for less than one-half percent of the total dispatched calls for service and less that nine percent of the emergency calls. Yet both of the primary clusters, four of the secondary clusters during 1997, and three of the secondary clusters during 1998 recorded funeral escorts as a vast majority of their cases or emergency calls (Table 9). While funerals are not emergencies, providing escorts is an important service function. However, the funerals do require the expenditure of police resources on an

[4] as noted by Jefferis et al (1998) SaTScan is not designed to be an extension or add-on for any particular GIS or automated mapping program. So managing the data for use in a GIS can be arduous.

Table 8: SaTScan Statistics - Emergency Calls

Incident/ Hazard	Year	Cluster ID	Type	N of Reporting Areas	Cases	Expected	Relative Risk	Log-Likelihood Ratio	P- Value
Emergency	1997	1	Primary	1	225	25.24	8.914	293.37	.001
	1997	2	Secondary	1	79	16.12	4.899	62.75	.001
	1997	3	Secondary	31	782	530.33	1.475	53.50	.001
	1997	4	Secondary	1	117	41.47	2.821	45.95	.001
	1997	5	Secondary	32	190	98.96	1.920	33.08	.001
	1997	6	Secondary	2	21	1.84	11.38	31.93	.001
	1997	7	Secondary	1	45	13.96	3.223	21.64	.001
	1997	8	Secondary	8	294	218.63	1.345	11.84	.006
	1997	9	Secondary	28	130	84.52	1.538	10.53	.020
	1997	10	Secondary	2	96	58.12	1.650	10.32	.027
	1997	11	Secondary	7	419	334.93	1.251	9.92	.038
Emergency	1998	1	Primary	1	260	37.57	6.921	281.58	.001
	1998	2	Secondary	1	112	31.76	3.527	61.05	.001
	1998	3	Secondary	1	104	28.03	3.710	60.49	.001
	1998	4	Secondary	20	600	372.62	1.610	59.53	.001
	1998	5	Secondary	26	1157	903.40	1.281	34.05	.001
	1998	6	Secondary	3	60	20.19	2.971	25.56	.001
	1998	7	Secondary	48	230	141.69	1.623	23.27	.001
	1998	8	Secondary	1	34	8.01	4.245	23.17	.001
	1998	9	Secondary	13	601	465.80	1.290	18.34	.001
	1998	10	Secondary	2	135	88.05	1.533	10.79	.019



Significant Clusters:
Emergencies 1997
Cluster Type
Primary
Secondary
Cluster Number
10
Boundaries
Bureau
Reporting Area
2 0 2 4 Miles
0.7 0 0.7 1.4 Miles
N
1
2
3
4
5
6
7
8
9
10
11

Figure 25.0

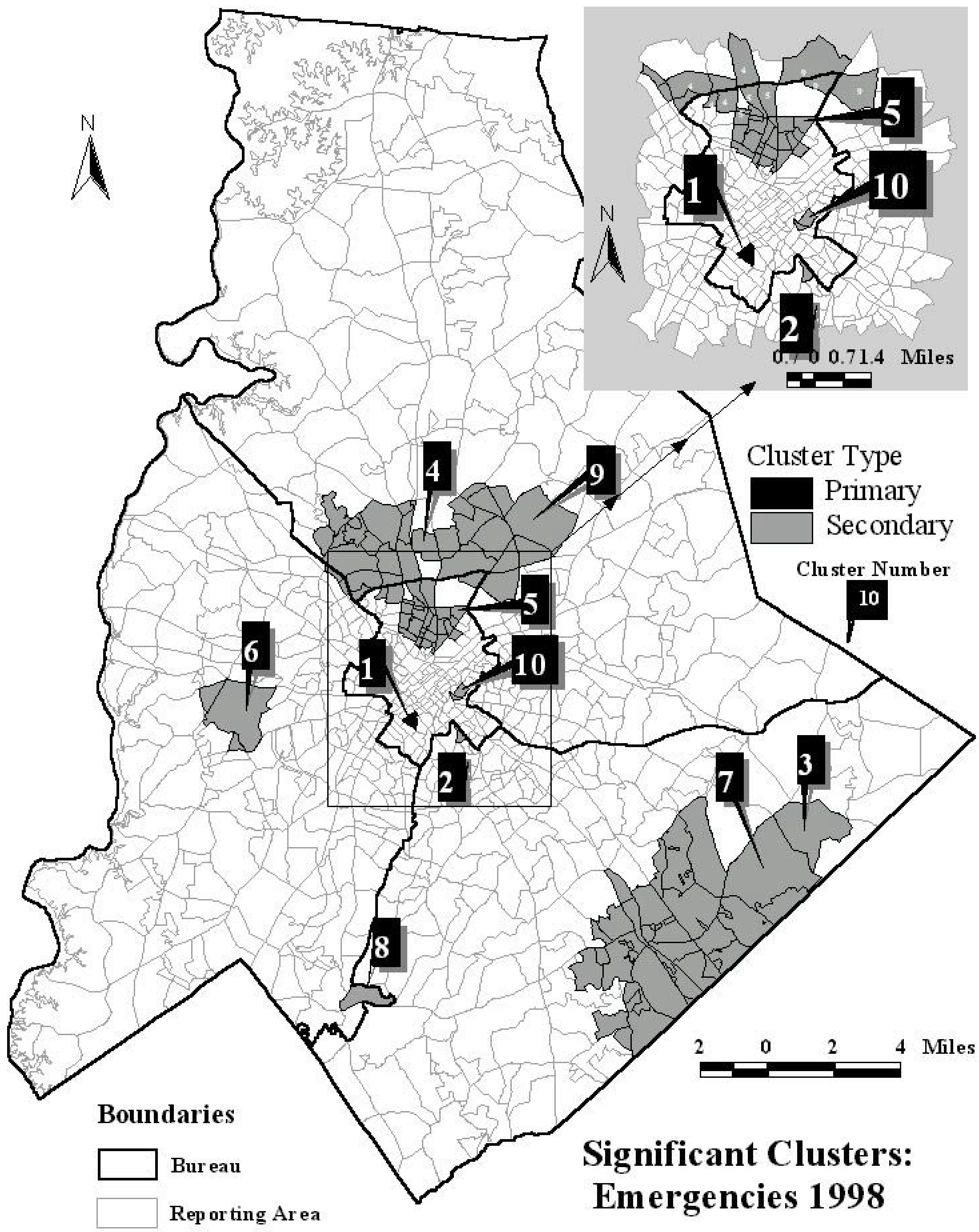

Cluster Type
Primary
Secondary
Cluster Number
10
1
2
3
4
5
6
7
8
9
10
2 0 2 4 Miles
Boundaries
Bureau
Reporting Area
Significant Clusters:
Emergencies 1998

Figure 26.0

Table 9: Significant Emergency Clusters & Funeral Escorts

Year	Cluster ID	Cases	Funeral Escorts	% Escorts
1997	1	225	220	97.8
	2	79	77	97.5
	3	782	185	23.7
	4	117	9	7.7
	5	190	87	45.8
	6	21	21	100.0
	7	45	35	77.8
	8	294	55	18.7
	9	130	3	2.3
	10	96	52	54.2
	11	419	71	16.9
1998	1	260	235	90.4
	2	112	78	69.6
	3	104	70	67.3
	4	600	177	29.5
	5	1157	178	15.4
	6	60	2	3.3
	7	230	45	19.6
	8	34	28	82.4
	9	601	94	15.6
	10	135	3	2.2

emergency basis which could tie-up important resources at very critical times. The only way to deal with this type of hazardous incident, if it is a problem, is through planning and policy change[5].

The other secondary clusters during 1997(3, 4, 5, 8, 9,11) and 1998 (4, 5, 6, 7, 9, 10) have a diversity of emergency calls. Some of the secondary clusters partially overlap between the years (e.g., 3 in 1997 and 4 in 1998). Some clusters disappear after one year (9 during 1997). Still other clusters appear to shift between the years. For example, Cluster 4 during 1997 with 117 emergency calls is one of the reporting areas incorporating the airport but during 1998 the number of emergency calls plummeted to 14. Adjacent is Cluster 6 which includes three other reporting areas incorporating the

[5] Funeral escorts, since September 2000, are provided by the Mecklenburg County Sheriff's Department.

airport. This cluster had 60 emergency calls during 1998, but only 7 during 1997. The abrupt changes in the data are inexplicable.

Table 10 displays the SaTScan statistics for *Gun Assaults & Armed Robberies*, *Use of Force*, and *Injuries*. Having lower counts than the emergency calls for service is one reason why there are fewer secondary areas for these incidents. As a matter of fact, there are only primary clusters for the use of force (Table 10).

The clusters for *Gun Assaults and Armed Robberies* are portrayed in Figures 27.1 and 27.2. The primary cluster for both years overlap but the 1997 cluster has a greater areal extent to the west, northwest, north, and northeast. The 1998 cluster, although much smaller than 1997, has greater southern coverage. The similarity between the two is that they encompass 61 percent (1997) and 60.9 percent (1998) of each year's *Gun Assaults and Armed Robberies*. Both clusters encompass the central city. The difference between the primary clusters is that during 1997 there were a few incidents committed in reporting areas generating lower levels of calls for service, thus creating high rates in reporting areas that are adjacent or near reporting areas generating high volumes of calls for service and gun assaults-armed robberies. The result is that the rates among the reporting areas are similar yielding the large cluster during 1997. The 1998 primary cluster is such because the outer reporting areas did not experience the rare events as they did during 1997.

The secondary clusters of *Gun Assaults and Armed Robberies* are important. During 1997, SaTScan isolated two single reporting area secondary clusters (Figure 27.1). Cluster 2 refers to gun assaults that occurred in and around an apartment complex on Eastway Drive. Cluster 3 in the south emerges because of 6 armed robberies that occurred in the 9500 Block of South Blvd.

Table 10: SaTScan Statistics:_Gun Assault & Armed Robberies; Use of Force; and Injuries

Hazard	Year	Cluster ID	Type	N of Reporting Areas	Cases	Expected	Relative Risk	Log-Likelihood Ratio	P-Value
Assault Robbery	1997	1	Primary	364	2159	1726.31	1.251	107.51	.001
	1997	2	Secondary	1	14	0.56	24.800	31.54	.001
	1997	3	Secondary	1	6	0.04	142.420	23.79	.001
	1998	1	Primary	354	1945	1546.55	1.280	327.56	.001
	1998	2	Secondary	4	150	84.21	1.781	21.08	.001
	1998	3	Secondary	2	100	58.22	1.718	12.42	.006
	1998	4	Secondary	3	17	3.91	4.350	11.91	.009
	1998	5	Secondary	1	15	3.14	4.781	11.61	.012
Use of Force	1997	1	Primary	292	226	159.48	1.417	22.05	.001
	1998	1	Primary	115	139	69.26	2.007	34.39	.001
Injuries	1997	1	Primary	1	13	0.95	13.638	22.17	.001
	1997	2	Secondary	134	102	55.33	1.843	20.72	.001
	1998	1	Primary	110	77	35.81	2.150	22.25	.001

During 1998, 1997's Cluster 3 is combined with two more reporting areas to become 1998's secondary Cluster 4 (Table 10 and Figure 27.2). Thus, it appears the modeling is picking-up an emerging problem area. Other 1998 secondary clusters merit illumination. Cluster 5 in the east reflect a series of gun assaults that occurred in a strip mall on Albemarle Rd east of Dwight Ware Rd (Figure 27.2). Returning to the west, Cluster 4 reflects armed robberies occurring in two reporting areas that are near an interstate ramp. This geographic feature provides easy access to and escape from numerous targets

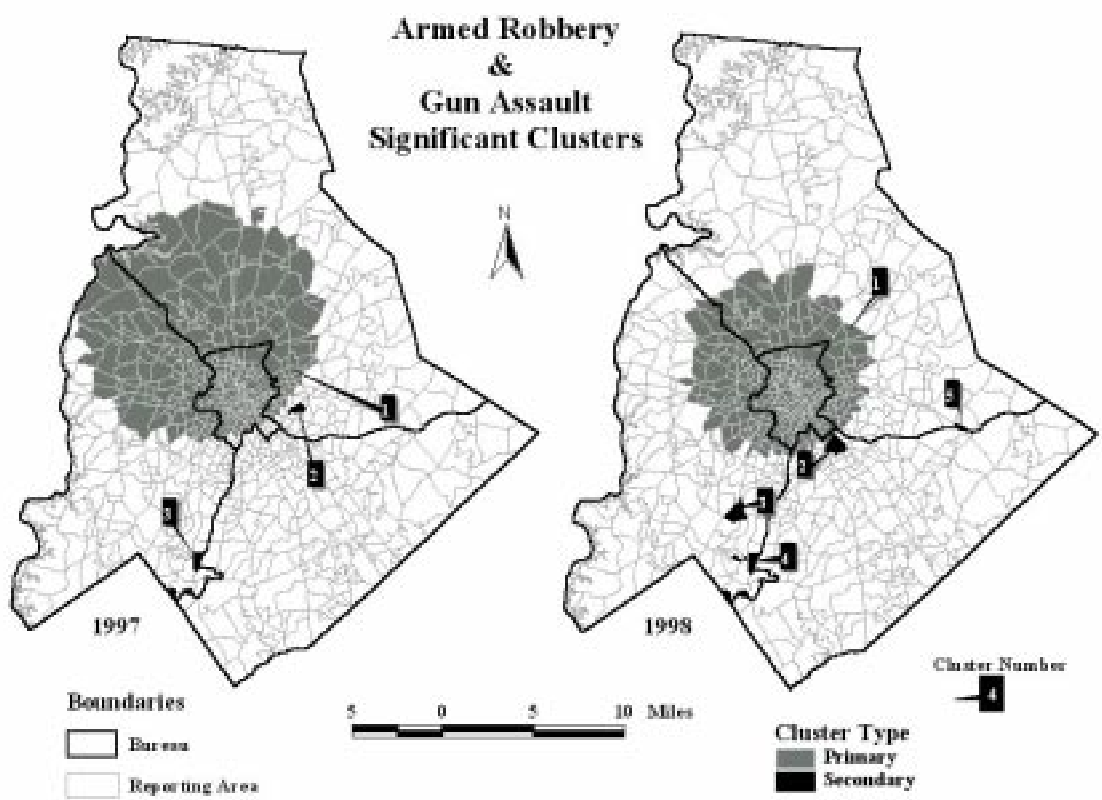


Figure 27.1 **Figure 27.2**

The last secondary cluster during 1998 is number 2 (Figure 27.2). This cluster is in BDR Baker 12 or as this place is more commonly known – Grier Heights. The residents of this area are lower income minorities living in owner occupied and renter dwellings mixed with other land uses. This area is a perpetual problem spot. During

1998, Grier Heights emerged as the most significant secondary cluster for gun assaults and armed robberies.

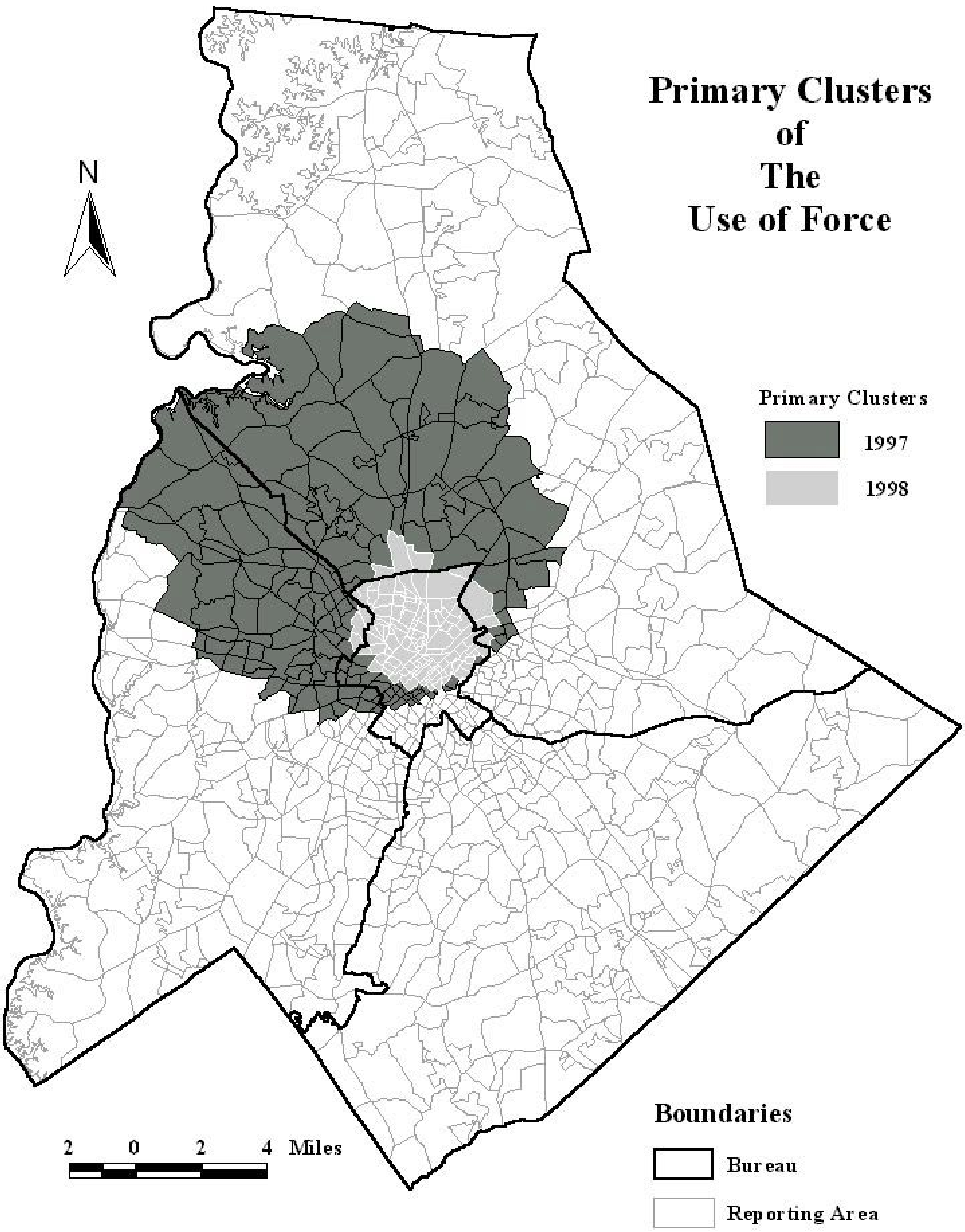


Figure 28.0

So far, SaTScan has been very proficient in isolating large contiguous areas with similar rates and isolating very small areas with very high rates.

Figure 28.0 depicts the primary clusters for the *Use of Force* for both years. The reason for the large *Use of Force* cluster during 1997 is the same as the large cluster for *Armed Robberies and Gun Assaults* during 1997. There were just a few of these events in reporting areas that do not generate large volumes of calls for service, thus producing high rates. Over 55 percent of the *Use of Force* incidents during 1997 are in the primary cluster. The primary cluster contracted during 1998 to include only 32 percent of the total incidents, yet the risk rates and the log likelihood ratios are higher. The areal extent of the 1998 cluster is confined to the older portion of the city and the central business district in the David Bureau.

The *Injury* clusters are depicted in Figures 29.1 and 29.2. At the onset it seems a bit odd that the secondary cluster during 1997, with over 41.6 percent of all the injuries across 134 response areas is not the primary cluster. The reason for this is due south of the 1997 secondary cluster where one encounters the primary cluster (Table 10 and Figure 29.1). The primary cluster records 13 injuries, but what has made this single reporting area so statistically prominent is the that eight of the injuries occurred when eight police officers went into a burning apartment to rescue its residents, hence the eight officers were treated for smoke inhalation and singed hair. Otherwise the major foci of injuries to officers are the 1997 secondary cluster and the 1998 primary cluster with the latter accounting for 36.6 percent of all the injuries.

Figure 30.0 depicts the reporting areas that are only in the 1997 secondary cluster; reporting areas that are only in the 1998 primary cluster; and reporting areas that are part of both clusters. By now the reader should be familiar with the area depicted in Figure 30.0 because it has been the prominent space for other hazards, incidents, and calls for service. The injuries, in this area during both years, run the gamut of causes ranging from an officer slipping on wet grass during a foot pursuit to injuries received from an automobile accident to an officer being wounded by a suspect.

This model has identified high-risk injury areas that are spatially consistent across two years, although additional research is in order to assess if the risk areas are diffusing from the southwest to the northeast (Figure 30.0). In an organizational context,

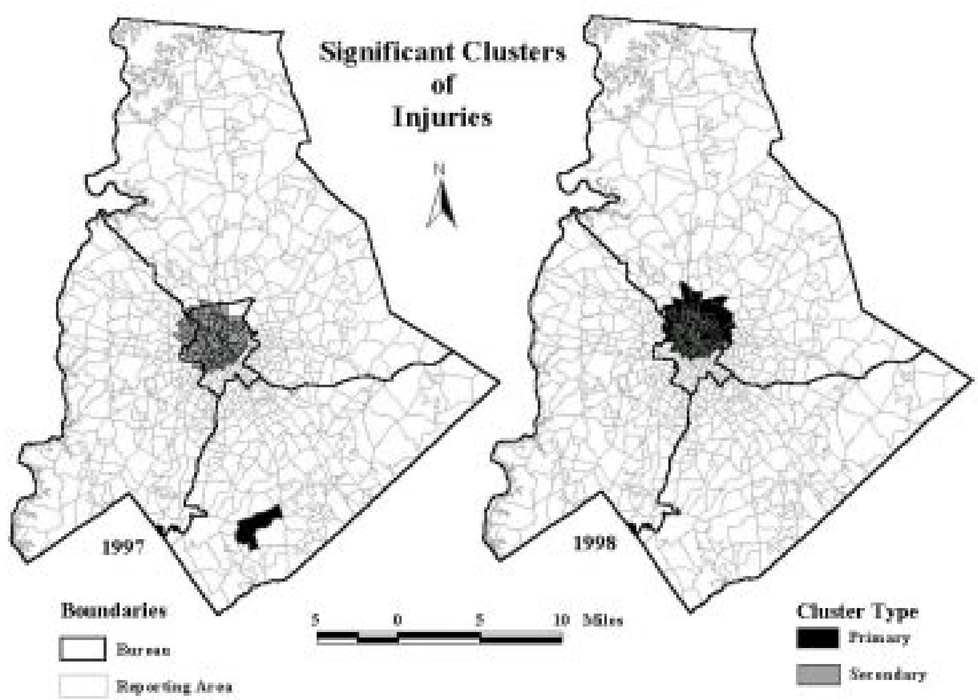


Figure 29.1 **Figure 29.2**

it is important to note that Figure 30.0 illustrates that the majority of the high injury risk areas are confined to one organizational unit mainly the David Patrol Bureau. This type of analysis could be done on a routine basis in order to monitor the nature,

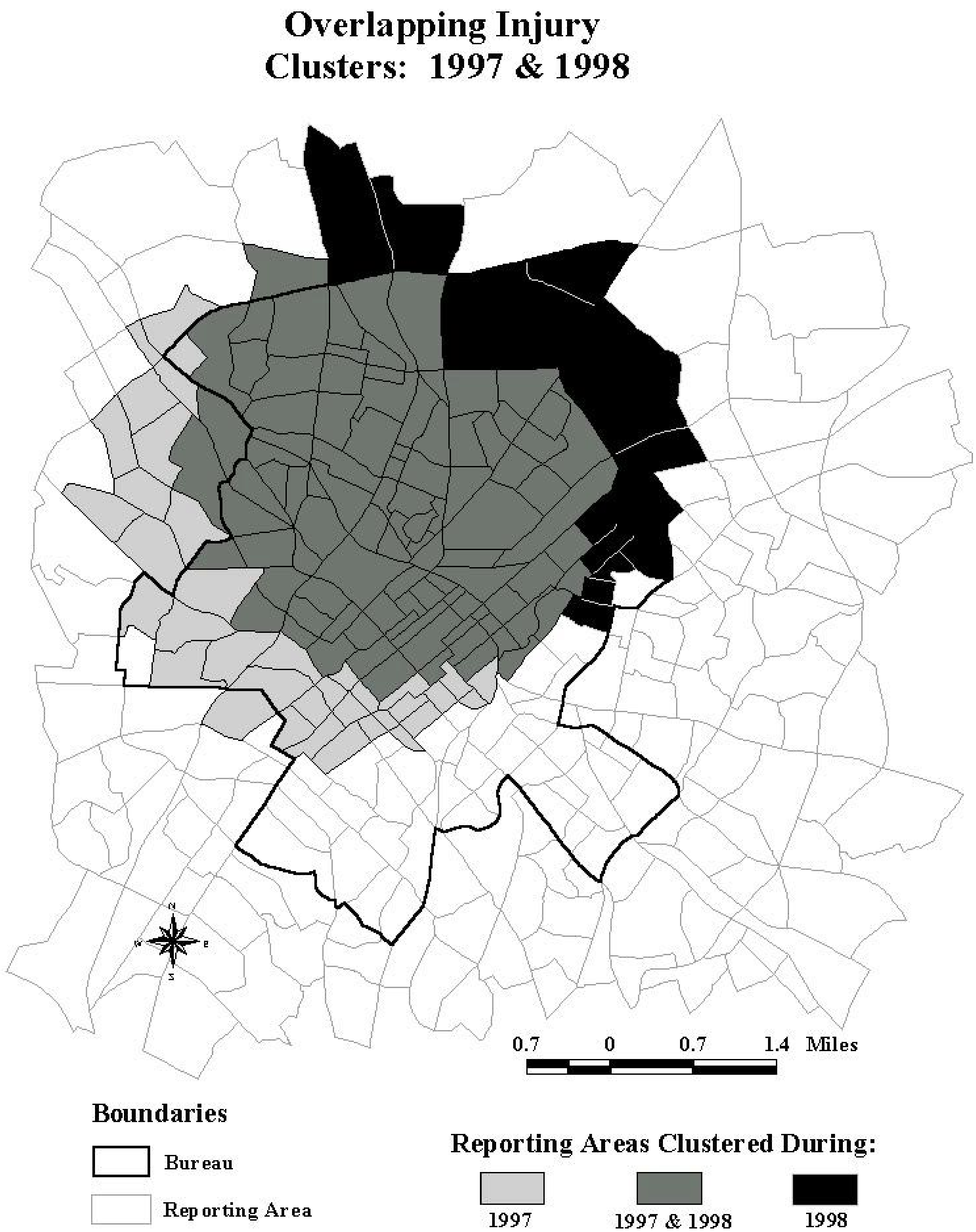


Figure 30.0

situational context, and spatial distribution of injuries in the David Bureau and other patrol bureaus as a precautionary measure.

Conclusions

Two methods for using GIS and spatial analysis software for delineating hazardous space for police work have been discussed. The first method classified urban space based on the combined densities of hazardous incidents. The second method employs the SaTScan spatial scanning software for clustering high risk reporting areas. This approach involved calculating risk rates by using the total number of calls for service for each reporting area as the denominator. The results from both approaches are encouraging, but are suggestive rather than definitive. The models have shared and individual constraints or obstacles.

Using density and probability, both approaches have empirically defined hazardous and high-risk areas relative to Charlotte-Mecklenburg, but we do not know how Charlotte-Mecklenburg compares with other jurisdictions across the country. In reality, Charlotte-Mecklenburg may well be one of the safest places for one to be involved in the policing profession. Therefore, a baseline needs to be established by employing the hazardous space models across multiple jurisdictions. Just as Wilson (1968) found Varieties *of Police Behaviors,* it is just as likely that there are varieties of police officer safety.

The major constraint with the density model is determining the grid size because different sizes can over and under estimate the density of hazardousness. While this issue is further examined, it might be best not to rely on one map of hazardous areas, but rather multiple maps employing different grid sizes might be more prudent (See, Monmonier, 1993: 96-97).

The SaTScan model requires additional testing including the use of different denominators for calculating risk rates. For example, many of the *Help Me Quick* calls emanated from police officers who were working off-duty. Thus, a valid rate would include a denominator measuring the average or number of police officers working off duty. Another example pertains to injuries. One of the common injuries experienced by police officers is being sprayed in the eyes with pepper spray during a scuffle with a suspect. The source of the spray is not the suspect, but other police officers who accidentally spray an officer. Thus, a proper denominator for this type of injury should be the number incidents involving pepper spray. The point is that more research needs to be pursued searching for valid and reliable denominators. Finally, the impending release of Census 2000 information will provide another set of denominators for assessing risk areas.

There has been little discussion about the geography of the hazardous spaces such as isolating the spatial processes, interactions, and the contents of places that generate the hazardous circumstances. Sparingly, I have alluded to possible independent variables and circumstances, but this is another matter for additional research. However, altering any ecological or demographic variables causally related to hazards would involve a long-term process. Changing these conditions may significantly and positively change a range of societal ills.

Presently, for the short-term, reducing hazards and ensuring safety for police officers has emanated from training and enacting policy. The short-term approach could be greatly enhanced by employing geographic information systems and examining important variables related to hazards that could be modified by policy intervention. For example, officer fatigue has long been a positive correlate of accidents and injuries.

Recent research suggests there are policy means for reducing the probability of officer fatigue through work shift design and compressed scheduling (Vila, 2000). Using GIS it would be possible to delineate and visualize the fatigue and hazardous spaces and assess the relationships between the two.

Mapping Out Special Events

Introduction

The third part of this project involves using GIS for mapping police activities during special events. Normally we think of special events as being the human-made social constructions for which time and activities are allocated. Holidays are special events and often the police may have special plans for delivering services. Accidents are special events for which the police have contingency plans (e.g., airliner crash; hazardous material spills; massive traffic pileups). Moreover, the police have other contingency plans and policies for dealing with demonstrations and unruly mob behavior emanating from special events like protest demonstrations and celebrations of the achievements of athletic teams. The special event of interest in this research is not human-made but it is of natural origin. Specially, we are examining flash flooding emanating from rainfall.

Flash floods are important to examine for two reasons. First, they are costly in terms of loss of life and property. On July 23, 1997, Charlotte, Mecklenburg experienced a 100 year flood where the amount of rainfall during a 24 hour period exceeded 11.0 inches. Rainfall of 7.09 inches for a 24 hour period is expected every 100 years(Robinson, et al, 1998: p. 3). Large portions of Charlotte-Mecklenburg exceeded this amount by almost 4 inches. As a result, three people were killed and property damage exceeded $60 million. (Robinson, et al, 1998). Second, events like these are becoming more frequent. Previously, in August 1995, Charlotte-Mecklenburg experienced a 100-year flood with no loss of life and $4 million in flood insurance claims and another $1 million dollars issued in loans to repair damage (Robinson, et al, 1998). Morever, meteorologists and climatologists have noted that across the contiguous United States extreme-intense precipitation events, like those passing through Charlotte-Mecklenburg, are increasing(Karl and Knight, 1998). The point is that many parts of the country have and will continue to experience more of these damaging events. Thus, this portion of the research examines, graphically, how the Flash Flood of July 23, 1997 impacted the CMPD.

Essentially, three themes or areas are examined. The first uses a digital elevation model(DEM) data from the United States Geological Survey(USGS) in order to match calls forservice with their elevations or contours instead of a street address location. Density grids of calls are matched to contours in order to examine the relationship between elevation and calls during the flood. The second theme graphically demonstrates cross beat dispatching during the flood. Specifically, mapping out where patrol units came from to respond to calls outside their assigned response areas. Highlighted is one call where the result was one of the three fatalities during the flood. Finally, the standard GIS procedure of point-in-polygon matching is used to locate calls within the flood plain. This allows one to visualize how distinctive the events were on July 23.

Calls For Service, Density, and Contours

On Wednesday, July 23, 1997, severe thunderstorms and flooding struck Charlotte-Mecklenburg, North Carolina. The CMPD received and processed 2,156 calls for service, which were responded to by 2,658 patrol units. The week before on the July 16, 1,712 calls were received and responded to by 2,191 patrol units. Comparing the two Wednesdays, July 23 represented an increase of 444 calls and responses by another 467 patrol units. Clearly this volume of work was unexpected.

Figure 31.0 is an hourly graph of the number of calls on 23 July, the annual average number of calls for service, and the average precipitation for each hour. Comparing the

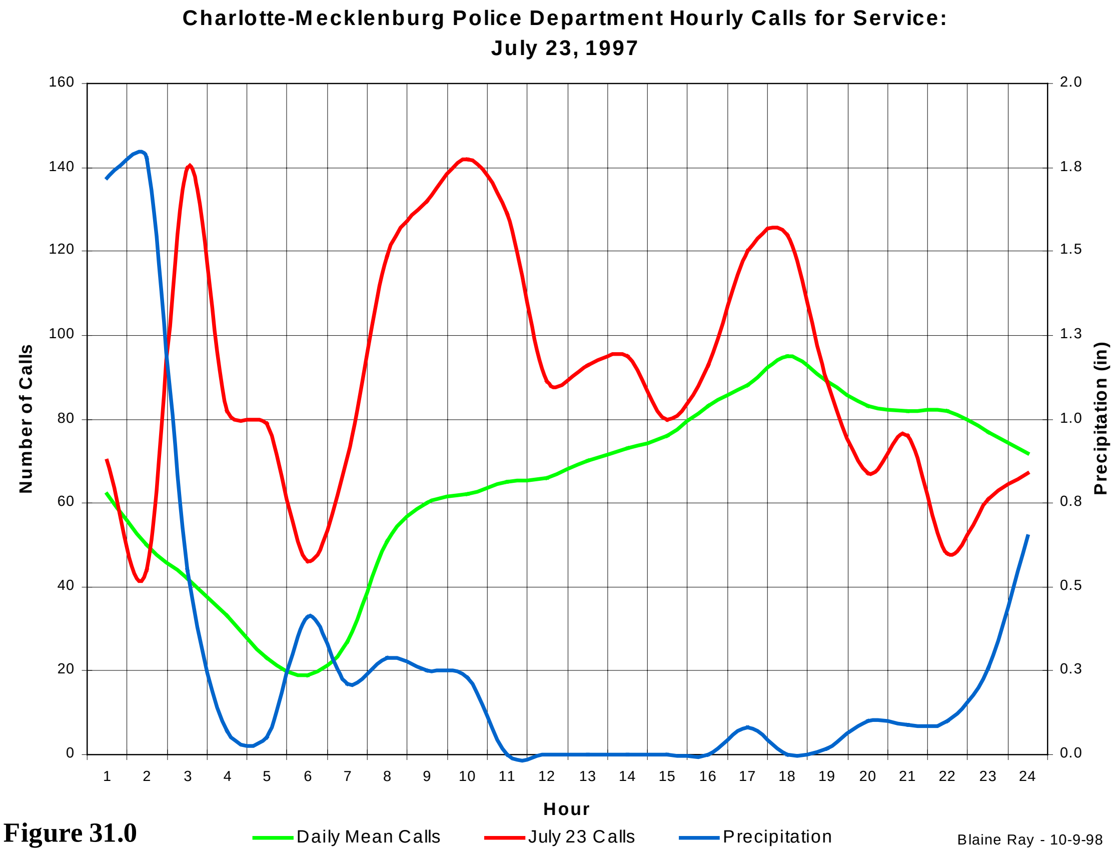


Figure 31.0

July 23 curve (red) with the average curve (green) we see that for almost every hour the July 23 calls were much greater than the average. The notable exception is after 1900 when the number of calls is much lower than the average. Normally, between 0200 and 0500 the number of calls on the average is approaching their lowest level for the day. The situation was opposite on the July 23. The precipitation curve shows, initially, a strong positive lag relationship with the number of calls. The very high precipitation amount at 0200 is followed by a very large number of calls at 0300. Moreover, if one inspects the curves closely it possible to see weaker positive lag relationships between the two curves.

Figure 32.0 is digital elevation model rendering of Mecklenburg County. An ArcView script was written to assemble the USGS quadrangles covering the county. This image provides an indication of the topography of the county its slope, aspect, elevation and

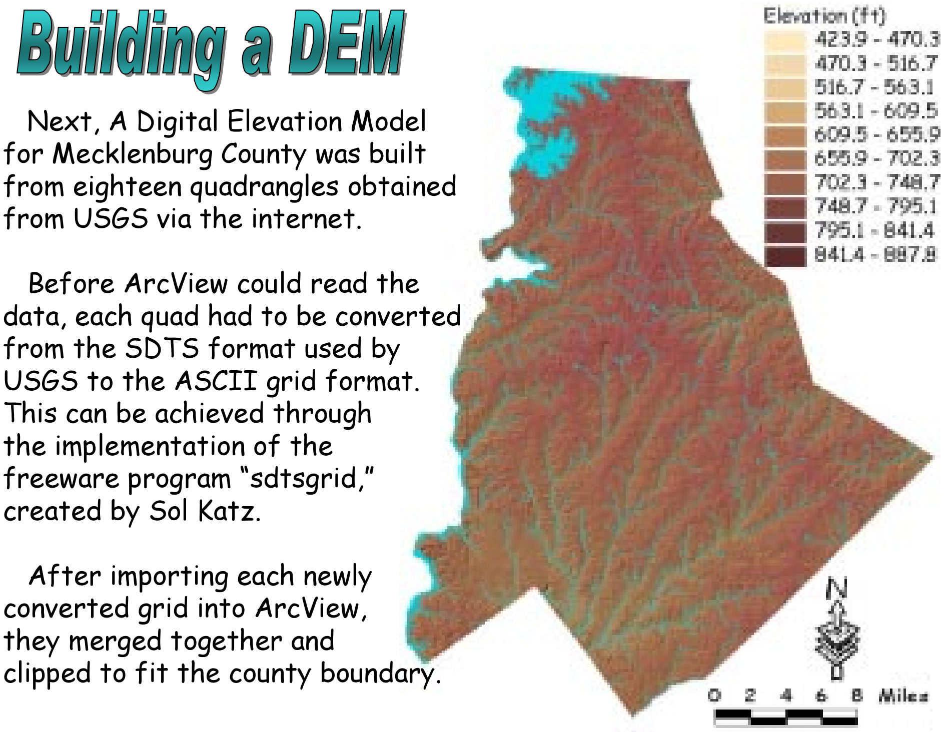


Figure 32.0

hydrography. The DEM allows one to take calls for service information that has been address matched and match the calls with the contours indicating elevation. Therefore, this enables one to measure the elevation of the calls.

The numbers and types of calls for service for the 16th and the 23rd were compared with the 23rd having many more accident or traffic related calls than the 16th. The accident related calls for both days were address matched. The point locations were then matched against the elevations and contours emanating from the DEM. Figure 33.0 is a graph of the percentage of the accident calls for both days plotted by their elevation. At some elevations, the percentage calls are parallel (e.g., 635) while at others the relationship or trend between the two days is negative – one increases while the other decreases (e.g., 680 or 695).

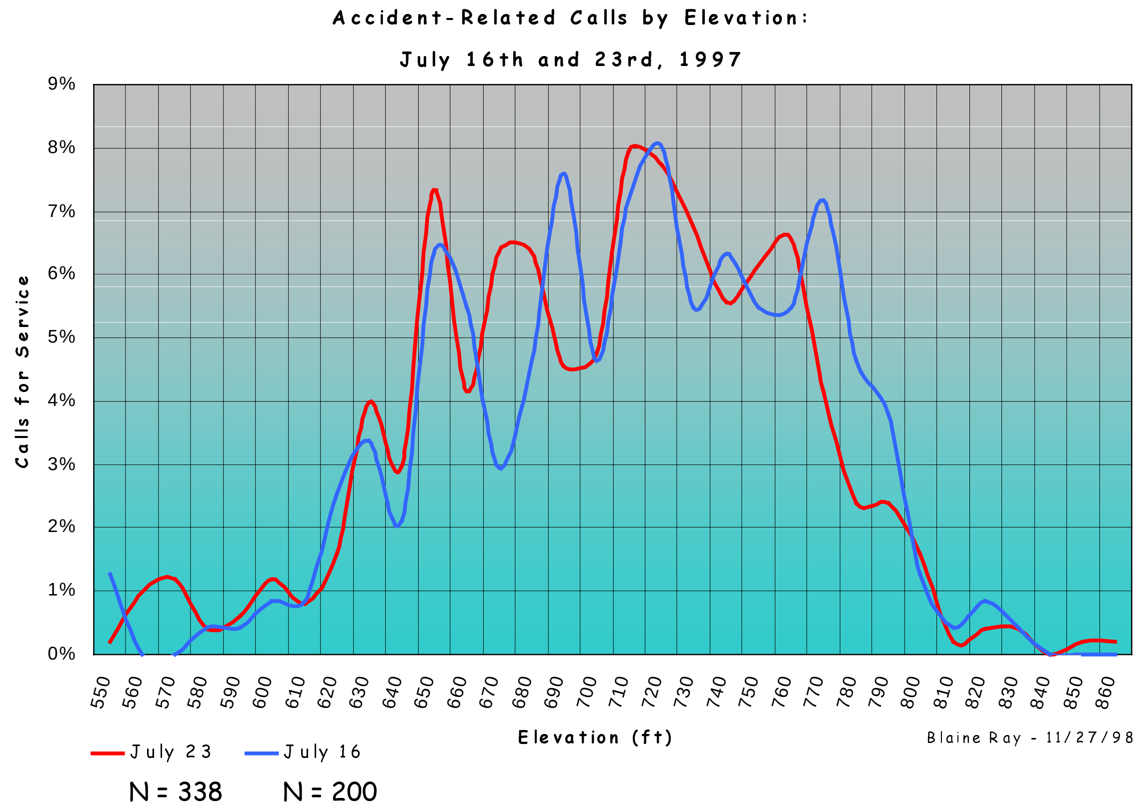


Figure 33.0

The 655 foot interval is selected as a threshold because this is the first point on the graph or in the series where the 23rd percentage beings to outpace the 16th percentage or there were 168 percent more calls within this threshold on the 23rd compared to the 16th. Figure 34.0 depicts the 23rd calls that are within the 655-foot threshold. Symbolic distinctions are made between traffic or accident related calls and other calls. Moreover, the DEM portions appearing in green are the contours within the threshold. Presumably these are the more flood prone areas in Charlotte-Mecklenburg given this methodology.

Figure 35.0 depicts the combination of two different pieces of important information.

Calls for Service Within the 655 ft Threshold

On July 23, 338 of the 2,156 total calls for service were within the 655 ft contour threshold.

Of these calls, 106 (31.36%) were requests to assist motorists, direct traffic, or assist with accidents.

There were 169% more calls for service within this threshold on July 23 than on the 16th.

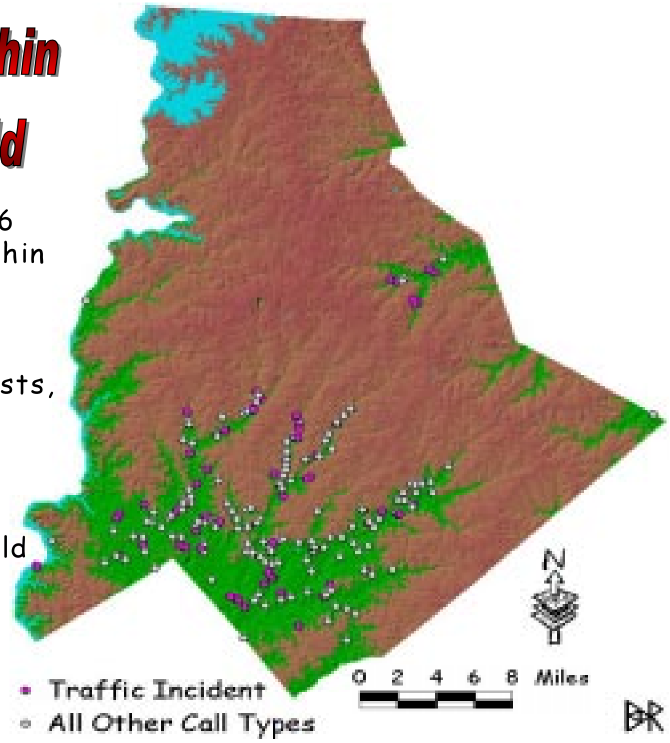


Figure 34.0

Selecting Areas of Mecklenburg County Subject to the Effects of Flooding

To find areas of the county likely to be affected by flooding, simply combine data layers obtained from previous steps into one overlay map.

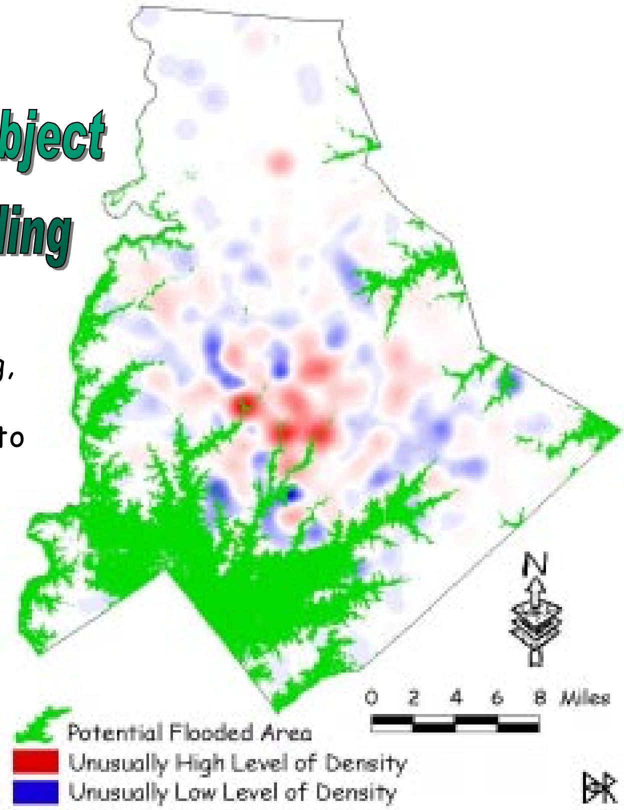


Figure 35.0

The first is a density grid which represents the difference in the densities of the calls for service for the 16th and the 23rd. Basically two density grids were constructed and then subtracted to create a third map that is the difference between the grids. The results presented in Figure 35.0 are the red areas that had an unusually high density of calls on the 23rd compared with the 16th with the blue areas having a unusually low density of calls on the 23rd. Viewed another way, the blue represents areas that had an extremely high density of calls on the 16th compared with the 23rd. The second piece of information portrayed is the threshold areas in green suggesting highly flood prone areas. Overlaying this information produces a map showing that a majority of the high call density areas on the 23rd of July were in or around flood zones.

Cross Beat Dispatching

The second area that was examined with GIS is cross beat dispatching during the July 23 flood. Cross beat dispatching is basically when a patrol unit is called out of its assigned area to respond to a call in another area. This issue is of particular concern to police patrol managers who are interested equalizing workloads among patrol areas and assessing the efficacy of shift schedules.

An ArcView script was written for this analysis. This origin and destination script takes a geocoded file of points and draws lines or vectors between the origin of the patrol unit and its destination. Moreover, the script allows one to aggregate the geographic units of analysis. Hence it is possible to examine and map vectors between a point and its destination area or between areas.

Figure 36.0 utilizes this script and plots out the interaction between response areas during the 16th and 23rd of July. This Figure does not differentiate between origin and destination, just the interactions between response areas. Furthermore, the vectors or lines between the response areas are graduated according to the number of interactions. Distinctive differences between the two days are quite conspicuous.

Assuming July 16 is a normal or average day, we see around the periphery of the county frequent and long distance interactions between response areas. Towards the center of the jurisdiction, we see several clusters of high frequency short distance interactions. Most of these movements are primarily local or intra-bureau or intra-district. The picture changes dramatically on July 23. First the number of interactions has increased. Secondly, finding distinct small clusters of interaction is difficult because the central part of the jurisdiction is totally obscured by cross beat dispatching. Finally, it is possible to see that a majority of the interactions or movements are inter-bureau and inter-district.

Figure 37.0 provides another view of the movement during July 23. In this visualization it is possible to ascertain directionality, origin, and destination. The large yellow circles are centroids of response areas while the smaller orange circles are the locations of the calls for service. Highlighted in Figure 37.0 is a particularly tragic call for service. A young child went outside to play in the rushing water and was swept away and found days later downstream drown. Twenty-five patrol units were dispatched to this call. Using graduated symbols it is possible to see the number of units emanating from specific response areas. Tabular materials in the form of interactions matrices can augment this or any graphic of cross-beat dispatching.

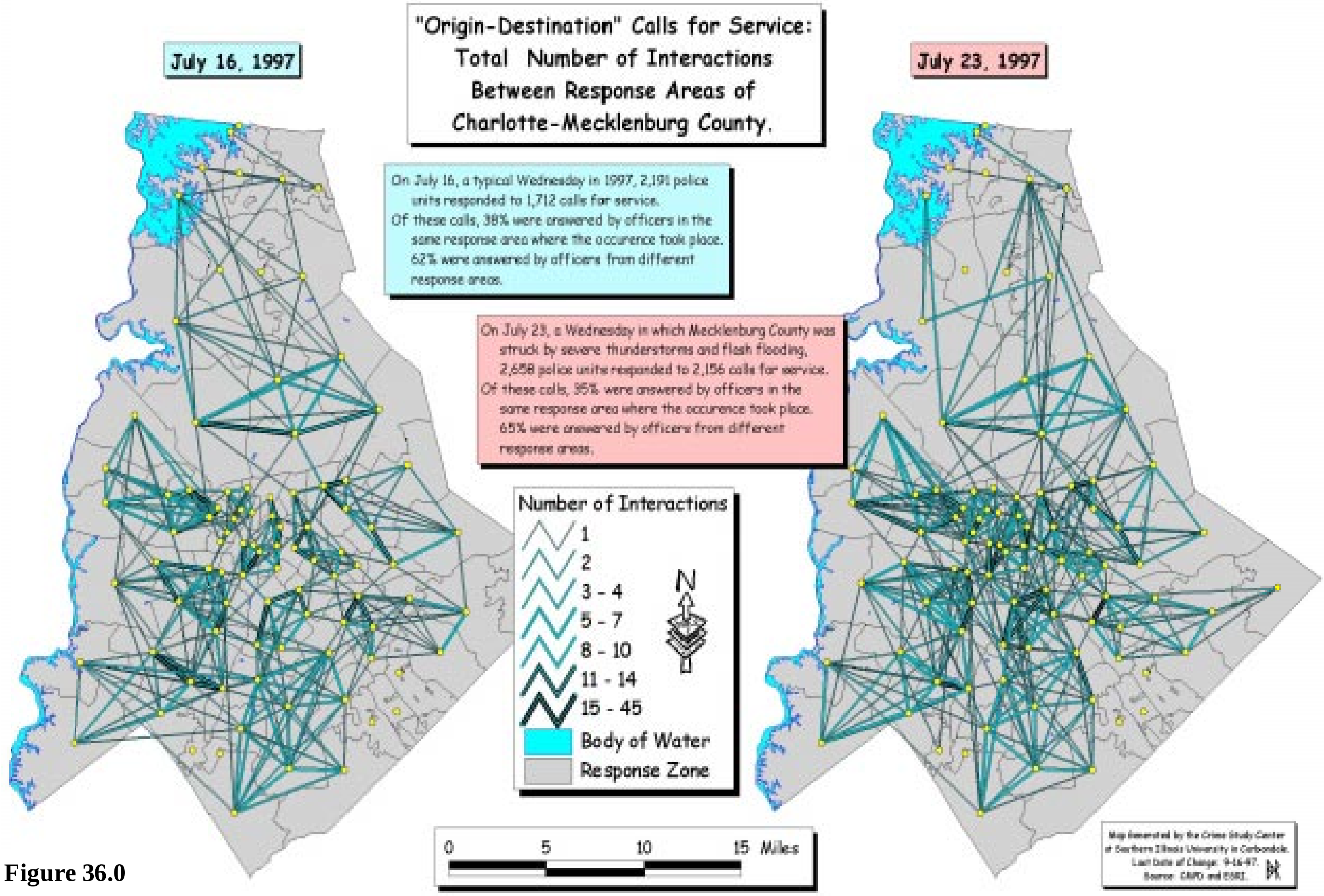

"Origin-Destination" Calls for Service:
Total Number of Interactions
Between Response Areas of
Charlotte-Mecklenburg County.
July 16, 1997
July 23, 1997
On July 16, a typical Wednesday in 1997, 2,191 police units responded to 1,712 calls for service.
Of these calls, 38% were answered by officers in the same response area where the occurence took place. 62% were answered by officers from different response areas.
On July 23, a Wednesday in which Mecklenburg County was struck by severe thunderstorms and flash flooding, 2,658 police units responded to 2,156 calls for service.
Of these calls, 35% were answered by officers in the same response area where the occurence took place. 65% were answered by officers from different response areas.
Number of Interactions
1
2
3 - 4
5 - 7
8 - 10
11 - 14
15 - 45
Body of Water
Response Zone
N
0
5
10
15 Miles

Figure 36.0

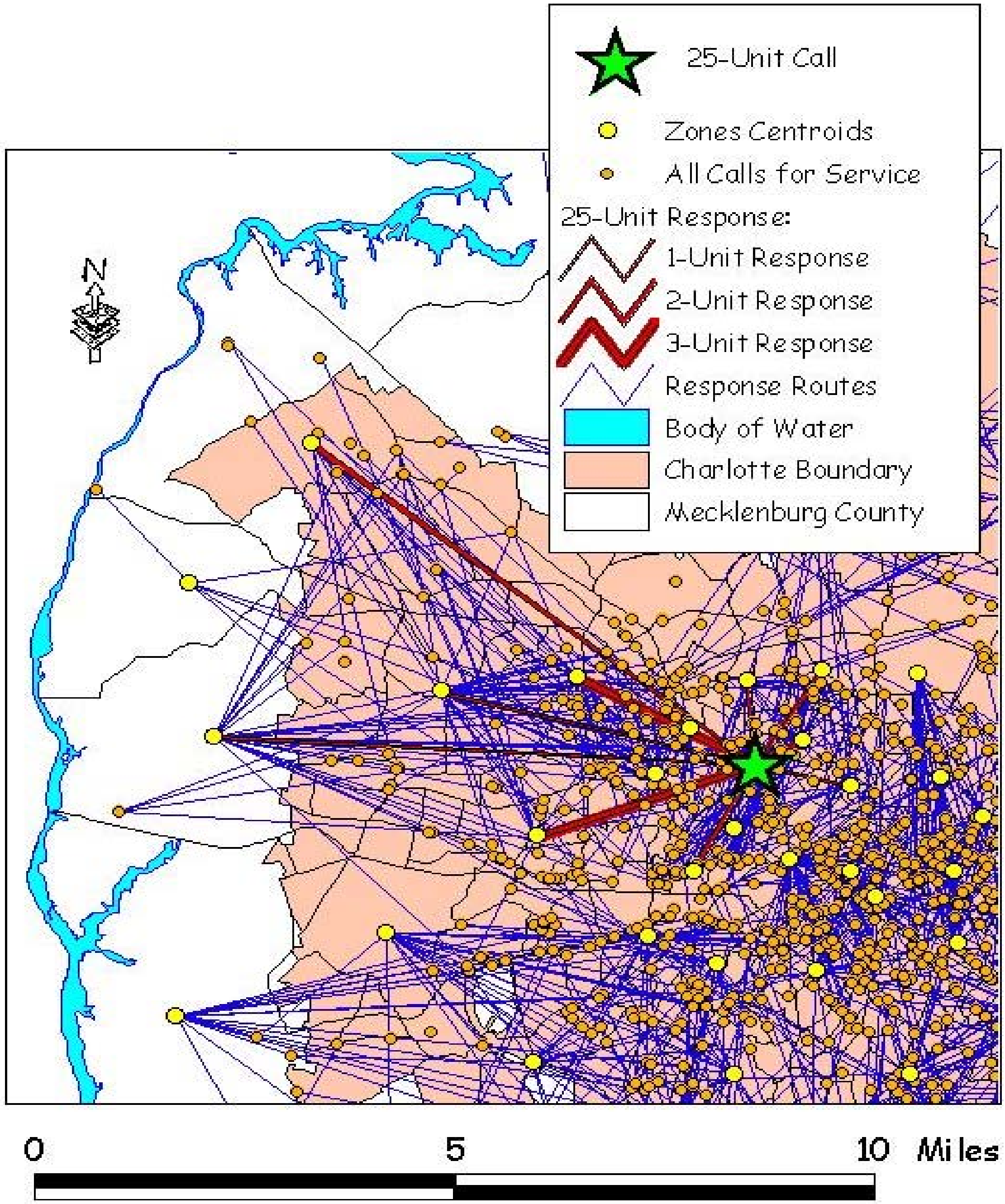

25-Unit Call
Zones Centroids
All Calls for Service
25-Unit Response:
1-Unit Response
2-Unit Response
3-Unit Response
Response Routes
Body of Water
Charlotte Boundary
Mecklenburg County
N
0
5
10 Miles

Figure 37.0

Calls For Service in the Flood Plain

Figure 38.0 displays important information from the events on July 23. First,

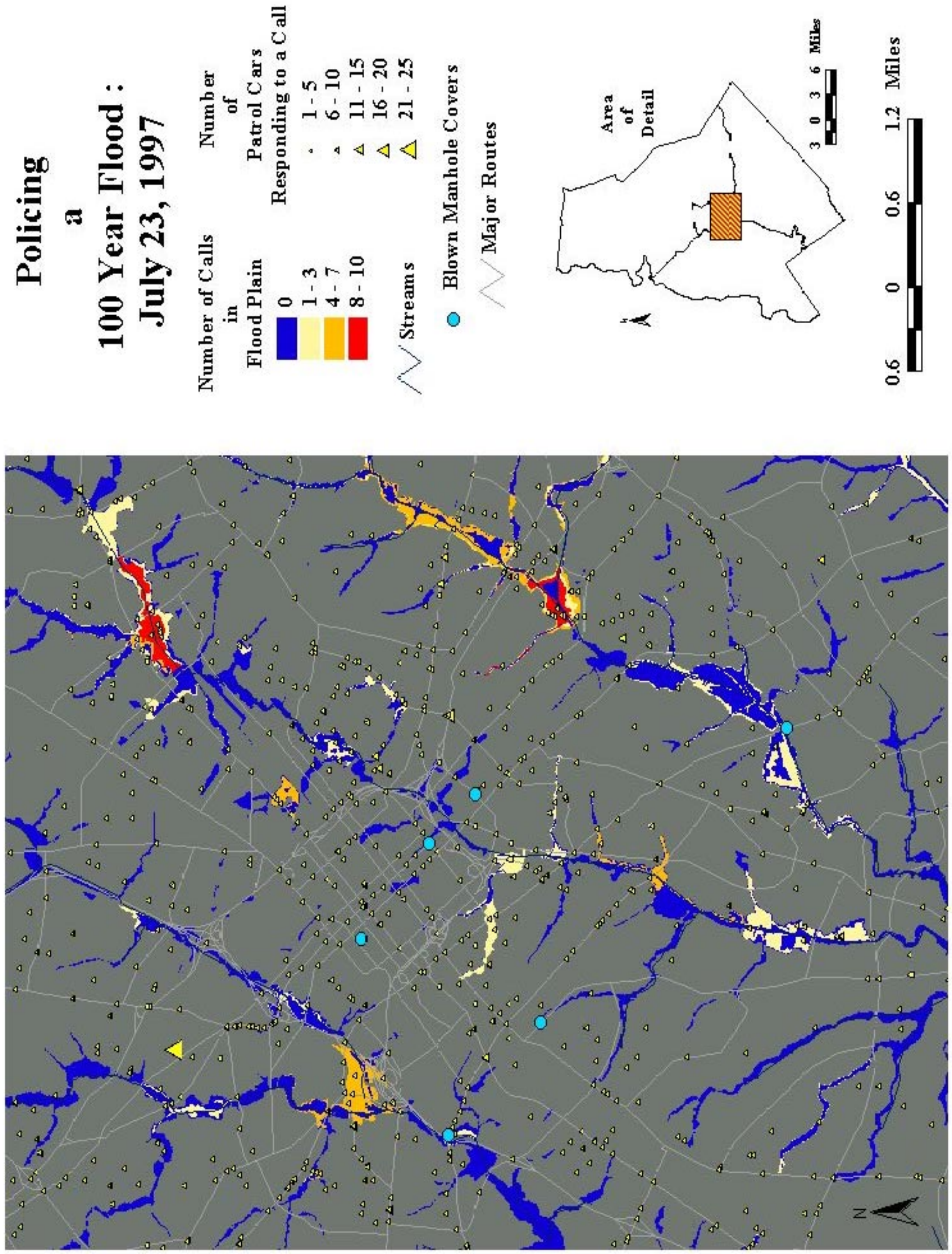


Figure 38.0

a polygon theme showing the flood plain is presented. The different segments of the flood are

Table 10: Percentage of Calls in the Flood Plain

Date	Day	N of Calls	N in Flood Plain	% in Flood Plain
2/16/97	Sunday	1063	26	2.45
2/19/97	Wednesday	1241	50	4.03
4/22/97	Tuesday	1233	52	4.22
5/4/97	Sunday	1195	18	1.51
5/11/97	Sunday	1214	35	2.88
6/16/97	Monday	1274	32	2.51
7/10/97	Thursday	1348	29	2.15
7/15/97	Tuesday	1273	43	3.38
7/16/97	Wednesday	1712	49	2.87
7/23/97	**Wednesday**	**2156**	**155**	**7.19**
8/5/97	Tuesday	1257	46	3.66
8/23/97	Saturday	1371	40	2.92
9/8/97	Monday	1217	27	2.22
9/15/97	Monday	1219	34	2.79
10/5/97	Sunday	1220	22	1.80
10/31/97	Friday	1431	36	2.52
11/10/97	Monday	1190	36	3.03
12/1/97	Monday	1259	24	1.91
12/23/97	Tuesday	1281	29	2.26
12/31/97	Wednesday	1286	35	2.72
	Average	*1322*	*40.9*	*2.95*

are choropleted or shaded according to the number of calls occurring within the flood plain. This is achieved by doing a point-in-polygon match of the geocoded calls for service with the flood plain coverage. Second, the locations of the calls are presented with a graduated symbol map (yellow triangle) based on the number of patrol units responding to the call. Third, the linear features of streams and major transportation routes are presented. Finally, a search of the dispatch records for that day uncovered six reports of manhole covers on the streets being blown. This is where the flow of water through the storm drain is so tremendous that pressure causes the manhole covers to pop or blow off into the street. The locations of the six blown manhole covers are depicted in Figure 38.0 with round cyan symbols, which are not exactly to scale. If they were, it would be impossible to see them.

The number of calls received on July 23 was greater than the week before (July 16) and greater than 18 randomly sampled days from 1997(Table 10). Moreover, the number and percentage of calls within the flood plain are much greater than the other days (Table 10). The usually high number of calls (155) within the flood plain contributes partially to the flood-induced workload. The remaining effects of the flood can be inferred from interpreting Figure 38.0.

The first piece of information gleaned from Figure 38.0 is that segments of the flood plains at or near the confluence of two streams or branches produced higher frequencies of calls than other segments. The geographic locations of the blown manhole covers infer flood problems from run-off as opposed to natural drainage. Four of the six manhole covers are not near flood plain segments generating calls for service. Three of these are in the central portion of Figure 38.0 with the two most northerly covers in the central business district.

The geographic positioning and clustering of the calls outside the flood plains also graphically suggests other places where flooding was a problem. For example, in the upper northwest portion of Figure 38.0, we see a large yellow triangle representing the 25 unit calls pertaining to the young girl who was swept away by the water. We know this was a flood related event, but the location is not near a stream or the flood plain. Due south of this location is a dense cluster of about 17 calls which according to the short descriptions on the calls for service records are related to flooding.

Conclusions

Many police agencies routinely examine their calls for service workloads for the purpose of allocating or reassigning resources. This discussion of Special Events provides two recommendations for those engaged in this process. First, the script for measuring and visualizing cross beat dispatching during the flood can be used in workload analysis for assessing shift schedules and geographic assignments.[6] Second, departments should engage in evaluating how special events of any type alter or change their operations. Moreover, these evaluations should be communicated and shared with other agencies.

[6] The code for this script is in Appendix A.

Summary and Conclusions

This project has demonstrated three different modules that require additional research and development. This is not because they could not be more fully addressed in this project, but rather they are evolving issues in the collaboration between policing and spatial analysis technology.

If maps are going to be useful, they have to be composed so that they effectively communicate their meaning to the user or reader (Monmonier, 1993). The status quo for visualizing the distribution of crime and calls for service is simply to display their point locations on a map or to aggregate points into larger areal units. Too often the latter over generalizes the distribution, while in order to make sense out of the former, other spatial techniques are needed to cluster and organize the point locations. The *Safe Streets* approach visualizes the magnitude and fluctuation of crime and calls by altering a feature of the urban landscape that police officers are intimately familiar with. Essentially this involves altering and mapping the size and color of street segments according to their intensity of a problem. The street segment is the basic unit of navigation for police officers.

GIS and spatial analysis are involved in the obvious application of analyzing the distribution of crime. This project has taken a different direction by applying the technology and methodology to the problem of identifying, analyzing, and mapping *Hazardous Space* for police work. Occupational safety is the primary focus here. More research needs to be conducted in this area to include both quantitative and qualitative assessments of safety and hazards.

It has long been known that the police do more than manage and control crime. The police, along with their firefighting and paramedic colleagues, are the first line of defense between the public and accidents, catastrophes, violent weather, and other *Special Events.* This project, combining non-police data with police data, demonstrates some mapping techniques for analyzing how a *Special Event* like a flash flood effects a city and police operations. This flash flood in Charlotte is like the killer tornado that swept through Oklahoma in May 1999 or the lethal heat wave that swept through Chicago during the Summer of 1995. The police had to respond, sometimes very quickly, to a range of non-routine circumstances. This research suggests new research partnership need to be formed between the police and those responsible for monitoring the environment.

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Appendix A: Code for Origin & Destination Script.

```
Name : ordestbr.ave
'
' Purpose : Displays origin-destination lines from:
'    (1) Zone centroids to other zone centroids, or
'    (2) Points to other points.
'
' Input : Requires three themes:
'    (1) A point theme representing a list of origin points,
'    (2) A point theme representing a list of destination points
'          **IMPORTANT** Both themes have to be ordered and have the
same
'            number of records in each (the first record of the origin
theme corresponds
'            to the first record of the destination theme).
'    (3) A polygon theme of zones that overlay ALL points in the two
aforementioned themes.
'
' Output : A new line theme with lines that originate at zone centroids
and terminate at
'    each destination point.  The attribute table of this theme will
have seven fields:
'    (1) A "shape" field
'    (2) A "length" field of values in the specified units for the
projection.
'    (3) A "origzone" field that contains the string for the line's
origin zone.
'    (4) A "destzone" field that contains the string for the line's
destination zone.
'    (5) A "count" field for the number of interactions from "origzone"
to "destzone."
'    (6) A "revcount" field for the number of interactions from
"destzone" to origzone."
'    (7) A "totalcount" field for the total number of interactions
between "origzone" and destzone."
'
'
' Author : Blaine Ray

theview = av.getactivedoc
thethemes = theview.getthemes
p = MsgBox.choice(thethemes, "Select The (Polygon) District Theme.",
"District")
if (p = nil) then exit end
o = MsgBox.choice(thethemes, "Select The (Point) Origin Theme.",
"Origin")
if (o = nil) then exit end
d = MsgBox.choice(thethemes, "Select The (Point) Destination Theme.",
"Destination")
if (d = nil) then exit end
typeflag = MsgBox.YesNoCancel("Select YES for point to point
analysis."+NL+"Select NO for polygon to polygon analysis." , "Select
The Type Of Analysis To Be Performed" , nil)
if (typeflag = nil) then exit end
```

```
statestable = theview.FindTheme(p.AsString)
statesftab = statestable.getftab
statesshpfield = statesftab.findfield("shape")
pshapeType = statesshpfield.GetType
list1 = list.make
list2 = list.make
list3 = list.make
list4 = list.make
list5 = list.make
list6 = list.make
Td = theview.FindTheme(d.AsString)
To = theview.FindTheme(o.AsString)
Proj = theview.GetProjection
TdFTab = Td.GetFTab
ToFTab = To.GetFTab
ShpFldd = Td.GetFTab.FindField("Shape")
ShpFldo = To.GetFTab.FindField("Shape")
oshapeType = ShpFldo.GetType
dshapeType = ShpFldd.GetType
countstates = statesftab.getnumrecords
if (tdftab.getnumrecords <> toftab.getnumrecords) then
  MsgBox.Error("The Origin And Destination Tables Must Have The Same
Number Of Records.", "Tables Don't Match.")
  exit
end
if (pshapeType <> #FIELD_SHAPEPOLY) then
  MsgBox.Error("You Entered The Wrong District Theme.", "Not A Polygon
Theme.")
  exit
end
if (oshapeType <> #FIELD_SHAPEPOINT) then
  MsgBox.Error("You Entered The Wrong Origin Theme.", "Not A Point
Theme.")
  exit
end
if (dshapeType <> #FIELD_SHAPEPOINT) then
  MsgBox.Error("You Entered The Wrong Destination Theme.", "Not A Point
Theme.")
  exit
end
fieldsp = statesftab.getfields
zonep = statesftab.FindField("zone")
if (zonep = NIL) then
  zonep = MsgBox.choice(fieldsp, "Select The Zones Field", "District
Theme")
end
if (zonep = NIL) then exit end

'Create lists for a polyline field, a count field, an origin zone
field,
'  and a destination zone field.  Also set up the status bar.

domore = av.setstatus(0)
av.showstopbutton

For each rec in statesftab
  progress = ((rec + 1)/countstates)*100
```

```
  domore = av.setstatus(progress)
  if (not domore) then break end
  apolygon = statesftab.returnvalue(statesshpfield,rec)
  zonename = statesftab.returnvalue(zonep,rec)
  for each record in ToFTab
    crpoint = ToFTab.returnvalue(ShpFldo,record)
    if(apolygon.contains(crpoint))then
       point1 = apolygon.returncenter
       point2 = TdFTab.returnvalue(ShpFldd,record)
       for each rec2 in statesftab
         apolygon2 = statesftab.returnvalue(statesshpfield,rec2)
         zonename2 = statesftab.returnvalue(zonep,rec2)
         if (apolygon2.contains(point2)) then
           point3 = apolygon2.returncenter
           if (typeflag = true) then
             line1 = line.make(crpoint,point2)  'point to point
             break
           else
             line1 = line.make(point1,point3)   'polygon to polygon
             break
           end
         end
       end

'Checks if list is empty to add the first line in to the empty list1
and
'  corresponding count into list2

      if(list1.isempty)then
        list1.add(line1)
        list2.add(1)
        list6.add(0)
        list3.add(zonename)
        list4.add(zonename2)
        linelength = line1.returnlength
        list5.add(linelength)


'Compares the line and its direction(by comparing end point values)
with lines
'  in list1 and adds it to the list if it is either unique(by value and
direction) or
'  not found in the list.  Initializes count to one

      else
        comp1 = list1.findbyvalue(line1)
        endpoint1 = line1.returnEnd
        startpoint1 = line1.returnstart
        if (comp1 = -1) then
          list1.add(line1)
          list2.add(1)
          list6.add(0)
          list3.add(zonename)
          list4.add(zonename2)
          linelength = line1.returnlength
          list5.add(linelength)
        else
```

```
          numrecs = list1.count-1
          for each indexnum in 0..numrecs by 1
            templine = list1.get(indexnum)
              if ((endpoint1.contains(templine.returnend)) AND
(startpoint1.contains(templine.returnstart)))
                then
                  counter1 = list2.get(indexnum)
                  list2.set(indexnum,counter1+1)
                  break
                elseif ((startpoint1.contains(templine.returnend)) AND
(endpoint1.contains(templine.returnstart))) THEN
                  counter2 = list6.get(indexnum)
                  list6.set(indexnum,counter2+1)
                  break
                end
            end
          end
       end 'outer else end
    end 'if
  end 'inner for end
end 'outer for end

'Create a line theme from the list of lines and add it to the view

class = PolyLine

'Specify the output shapefile...

def = av.GetProject.MakeFileName("theme", "shp")
def = FileDialog.Put(def, "*.shp", "Output Merged Shapefile")
if (def = Nil) then
  exit
end
lineftab = FTab.MakeNew(def, class)
countfield = field.make("count",#field_short,5,0)
revcountfield = field.make("revcount",#field_short,5,0)
origfield = field.make("origzone",#field_vchar,8,0)
destfield = field.make("destzone",#field_vchar,8,0)
lengthfield = field.make("length",#field_decimal,20,4)
totalcountfield = field.make("totalcount",#field_short,5,0)
lineftab.addfields({lengthfield, origfield, destfield, countfield,
revcountfield, totalcountfield})
shapefield = lineftab.findfield("shape")
loop = list1.count-1
for each i in 0..loop by 1
  newrec = lineftab.addrecord
  theline = list1.get(i)
  thecount = list2.get(i)
  therevcount = list6.get(i)
  theorig = list3.get(i)
  thedest = list4.get(i)
  thelength = list5.get(i)
  lineftab.setvalue(shapefield,newrec,theline.aspolyline)
  lineftab.setvalue(countfield,newrec,thecount)
  lineftab.setvalue(revcountfield,newrec,therevcount)
  lineftab.setvalue(origfield,newrec,theorig.asstring)
  lineftab.setvalue(destfield,newrec,thedest.asstring)
```

```
  lineftab.setvalue(lengthfield,newrec,thelength)
  lineftab.setvalue(totalcountfield,newrec, (thecount +
therevcount).asstring)
end
linetheme = ftheme.make(lineftab)
thelegend = linetheme.getlegend
thesymbol = thelegend.getsymbols.get(0)
thesymbol.setcolor(color.getblue)
linetheme.updatelegend

'Add theme to the current view

if (MsgBox.YesNo("Add Shapefile Theme To The View?", "Add To View",
true).Not)
  then
    exit
  end
theview.addtheme(linetheme)
linetheme.setvisible(true)
av.showmsg("")
av.clearstatus
av.GetProject.SetModified(true)
```