Measuring Patterns of Crime in Durham, North Carolina

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I. Introduction

A Geographic Information System (GIS) is a powerful cross-disciplinary tool that allows users to visualize spatially-related phenomena and make decisions much faster than in previous generations. While GIS has its roots solidly planted in the mathematical, computer and information sciences, it has made significant strides in its ability to integrate with social science research.

At North Carolina Central University (NCCU), coursework in GIS is offered through the Department of Environmental, Earth and Geospatial Sciences (DEEGS). However, students in a variety of disciplines take GIS coursework to supplement their existing skill sets. Faculty members in the Department of Social Work have seen the utility of GIS that they have made GIS a program requirement. Other departments in which GIS coursework is suggested includes Public Administration, Sociology and Criminal Justice.

In support of this social science research, DEEGS faculty have begun to consolidate data from sources transcending various subjects. While the DEEGS has existing data sources related to the earth and environmental sciences as part of its traditional curriculum, NCCU has begun acquiring local data related to criminal justice and public administration. NCCU has forged a relationship with the Durham City Police Department Crime Analysis Unit (CAU)[1] in which crime data for the city of Durham is supplied in tabular format to DEEGS faculty. These data are converted to a GIS format using *Add XY* command in ArcGIS. These data have been used as demonstration aids and in student class projects. Given that many NCCU students live and attended high school locally, they find this added dimension of research interesting, practical and applicable. Students have a vested interest in their community and this type of research looks to address some of the issues that affect NCCU students on a regular basis. This paper focuses on some of these findings.

II. Study Area

The City of Durham is located in the Research Triangle Region of North Carolina. It is located about 30 miles west of Raleigh and about 125 miles northeast of Charlotte, the largest city in the state. The North Carolina State Demographer cites the 2009 population of Durham at 234,140 while the 2010 Census places that value at 228,330. In either case, Durham is the 5th largest city in the state of North Carolina and amongst the 100 most populated cities in the United States. Another 35,000 people live outside of the Durham City limits, but within Durham County. While they may have a mailing address listed as Durham, they may also live within the municipalities of Chapel Hill, Morrisville, Butner and even Raleigh. Police services and the accompanying crime data for those living outside of the Durham City limits is provided by the Durham County Sheriff's Office. Because of the availability of data, only data for the City of Durham has been provided and will be analyzed.

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[1] Raw crime data were provided by Jason Schiess at the Durham Police Department, Analytical Services Manager (Jason.schiess@durhamnc.gov or 919-560–4258)

North Carolina Central University is located approximately 1 mile south of downtown Durham. The study area encompasses the 13 census block groups surrounding the campus (Map 1). While others such as Mennis et. Al. (2011) have divided urban areas into non-overlapping neighborhoods that were more homogeneous than their census-defined counterparts or even units based on self-organizing maps (SOM) used via data mining techniques (Spielman and Thill 2008), our familiarity with the City of Durham is still in it infancy. It was decided to save the organization of the city into homogenous and contiguous units for later studies. These census block groups were chosen in conjunction with a community engagement project that DEEGS faculty are undertaking with NCCU's Academic Service Learning Department. In this project, DEEGS faculty are using spatial data to give campus leaders a better understanding of the people and neighborhood surrounding campus.

Durham lies within The Research Triangle, the crown jewel of the state's economic future. To support this effort, various higher education institutions—including North Carolina Central University—have established new academic research initiatives to link university research to technological advancement which in turn facilitate community stability. Despite the civic resources fueling Durham's technological and economic growth, a considerable number of residents may not become part of the growth. As the Research Triangle grows, it will abut neighborhoods that are undermined by high crime rates, poverty, substandard housing, unemployment, health disparities, and economic disenfranchisement which ultimately manifest themselves in just more crime while fueling this vicious cycle.

Table 1 highlights demographic and economic data for this study area compared to the rest of Durham. This study area is marked with a high percentage of rental units (Map 2), vacant homes and lower income (Map 3). This high vacancy rate has unfortunately manifested itself in having an inordinately high number of abandoned homes and vacant homes, including many adjacent to the NCCU campus. As a result, the area is site of a number of Habitat for Humanity homes in the City of Durham.

Table 1: Basic information from study area versus the rest of the City of Durham

	Study Area	Rest of City
Population	17,792	216,348
Median Age	33.6	36.6
% Age Under 18	25.7%	22.9%
% Minority Residents	91.7%	44.2%
% Housing Units that are Rental	50.8%	37.8%
% of Housing Units that are Vacant	16.8%	8.7%
Median Household Income	$32,214	$61,362

III. Prior Research

A GIS serves as the tangible and intangible means by which information about spatially related phenomena can be stored, analyzed and mapped. Experts in many dissimilar fields have seen the utility of GIS as a means of quantifying and expanding their research. GIS is used in disciplines such as business, sociology, justice studies, surveying and the environmental sciences (Steinberg and Steinberg 2006). In fact, most data can have a spatial component applied to it. Crime can be modeled in a variety of different ways. A particular crime incident can be modeled as point and assigned a real world location such as an address or absolute location (latitude and longitude).

Information about this point can have a variety of attributes (day/time the crime was committed, address of crime).

Because of the limited capabilities of GIS software and affiliated resources, previous generations of crime analysis focused on the visualization of crime. Various mapping techniques and classification schemes such as quantiles, natural breaks and standard deviations were perfected (Harries 1999). Another early study by Li and Rainwater (1999) used GIS to visualize crime rates on the backdrop of other variables such as commercial land-use, household size and unemployment. Even earlier, Harries (1997) mapped 24 social stressors such as unemployment, poverty and at-risk youth to model and map clusters of areas denoted by this high stress around Baltimore, Maryland. In both cases, however, complex modeling needed to be performed outside of the GIS software. These 'loosely' coupled applications are not intuitive in nature, and therefore alienate basic GIS users. Regardless, great advances have been made since the time of Boggs (1965) in both the time and scope in which crime can be spatially analyzed.

In this day and age, ESRI and other analytical tools such as Crimestat (Levine 2004) can be used within one software umbrella to answer and address various dimensions of crime. Andersen (2006) explored the spatial dimensions of crime that can be explained by census variables. While he looked at this within the context of ambient population, indicators or crime such as home value, rentership, income and unemployment were shown to correlate with their resident-based crime rates. Other papers by Levine and Block (2011) as well as Bodnar (2007) applied advanced mathematical techniques to the visualization and modeling of crime which fall outside of the scope of this exploratory research.

Mapping crime around college campuses serves as a subset to the phenomenon of measuring spatial aspects of crime. The origins of the grand and structural theories, used to explain differences in international crime rates, can be explored at the local level. Quantitative indicators of social constructs such as the measure of civilization, the distribution of various cultural groups (Howard et. al. 2000), and the measure of strain via economic disparity (Neapolitan 1996) help to explain how and why crime occurs where and when it does. Empirical studies suggest that crime rates within the same demographic group, age, income level and urban cluster vary from place to place throughout the United States. Being situated in the South, Durham may experience higher rates of violent crime based in its unique culture and history (Ousey 2000, Erlanger 1976) that other parts of the United States may not experience. All of these factors need to be taken when dealing with crime.

Given the unique demographic nature of college campuses, the application of GIS to campuses has also been done in the past. The FBI and Flowers (2009) published a compilation of crime statistics and various dimensions of crime, but it has little spatial component. Brower and Carroll (2007) looked at spatial and temporal patterns of student drinking in the college town of Madison, Wisconsin. Stewart (2010) later used GIS to explore how university campuses may affect, among many other things such as housing prices, crime in a college or university community.

IV. Basic Crime Statistics for Study Area

Data were supplied to NCCU in tabular format. This information was converted to GIS format (File Geodatabase) using the *Add XY* command in ArcGIS. Crimes are mapped to their real world location using the northing (Y) and easting (X) relative to the North Carolina State Plane projection. Tabular information about each crime supplied by the Durham Police Department includes the following:

- Charge Description
- Day of the Week for Each Offense
- Location of Offense (Business, Open Area, Residence)
- Address
- Northing[2]
- Easting[2]
- Date (MM/DD/YYYY) of offense

[2] A random offset is applied to the northing and easing of crimes where privacy concerns are involved.

The study area was created from the 13 census blocks surrounding the NCCU campus. In ArcGIS 10, the *Dissolve* command was used to create a single polygonal study area from the 13 census block which were used for later queries. An *Erase* command was used to create to create a polygon that was within the city, but outside of the area of interest. This polygon was needed because few of the crime locations provided were actually outside of city limits. This could be for many reasons, some of which may include human error or cross-jurisdiction arrests. For the sake of expedience, this study only explored crimes within the city of Durham. From there, the *Select by Location* dialog was used to query crimes that occurred within the study area compared to the rest of the city.

In addition to spatial queries, attribute queries were performed to tease out the more serious crimes that occur within Durham. Crimes ranging from non-negligent homicide to truancy were captured by the police department. Obviously all of them are not equal. The Department of Justice (2004) has created a taxonomy where crime can be classified into 2 basic groups. Part I crimes represent violent and property crimes such as murder, robbery, forcible rape, arson, burglary, larceny-theft and motor vehicle theft. Part II crimes represent less serious crimes which include drug offenses, simple assault, vandalism, driving under the influence, disorderly conduct and fraud. Since the study area only encompasses a small portion of the city, raw crime values (# of crimes) were standardized by resident population to create a comparable metric across both study areas. 2007 data provided by ESRI were used for the population values. The results are highlighted in Table 2 below.

Table 2: Crime rates within study area and for rest of city, all and Part I crimes.

	Total Crime Rate (per 1,000 people)		Part I Crime Rate (per 1,000 people)	
	Within Study Area	Outside of Study Area	Within Study Area	Outside of Study Area
2007	184.4	102.7	79.5	54.8
2008	184.5	102.2	79.5	55.9
2009	179.1	98.2	79.9	53.8
2010	180.3	98.3	77.7	52.7

For the year 2010, 24,477 crimes were recorded for the city of Durham, with slightly more than half (12,773) being Part I crimes. 1,380 serious (Part I) crimes were recorded for the study area, representing 1 serious crime for every 12.8 people. As Table 2 articulates, crime rates within the study area are significantly higher than the rest of the city. There have been minor decreases in both crime rates since 2007. A further look at the types of Part I crimes being committed in the city is highlighted in Table 3. In addition to the study area, another area called "Immediate Area" focused on the 5 census blocks groups that contained or were directly adjacent to the NCCU campus. It was surmised that student housing, such as apartments and rental homes were largely found within this area. While the rates for burglary and larceny theft were comparable to the rest of the city in this "Immediate Area", rates for aggravated assault were twice the city average and rates for robbery and motor vehicle theft were almost as high as the study area.

Table 3: Part I Crimes in Study Area, Rest of City and Immediate Area for 2010.

	Rate per 1,0000 (number)		
	Within Study Area	Outside of Study Area	Immediate Area
Aggravated Assault	7.64 (136)	2.55 (551)	6.55 (41)
Forcible Rape	.51 (9)	.25 (55)	.32 (2)
Murder	.17 (3)	.09 (20)	.16 (1)
Robbery	5.40 (96)	2.63 (568)	4.32 (27)
Arson	.51 (9)	.09 (20)	.48 (3)
Burglary	24.22 (431)	14.94 (3232)	19.66 (123)
Larceny Theft	33.89 (603)	29.24 (6327)	22.86 (143)
Motor Vehicle Theft	5.23 (93)	2.87 (620)	4.80 (30)

V. Crime Change

In this study, crime rates are measured by the number of Part I crimes per 1,000 residents. Given the number of crimes and population for the given enumeration unit, these crime rates can be agglomerated at a number of different scales. Given the raw data for crimes and population, crime rates were computed for each census block group, the study area and the city of Durham. 127 block groups lie within this city limit. Partial census block groups were prorated based on the percentage of area that lay within city limits.

The number of crimes and accompanying rate were created using the *Intersect* function with the census block groups and crimes. By doing this, each crime can be assigned a location, in this case the Federal Information Processing Standard (FIPS) code for the census block group in which the crime was located. The FIPS code is a unique identifying 12-digit code used to distinguish it from all other block groups in the United States. Using the *Summarize* function, the sum of all crimes that occur within the same census block group can be tallied. Finally, this resulting table can be *Joined* to the GIS layer representing census block groups using the FIPS code as the primary key and mapped based on the crime rate, which is derived using the formula below using the tallied count and population values for each census block group.

$$CrimeRate = \frac{(1000)(NumberofCrimes)}{PopOfBlockGroup}$$

Crime rates from 2010 for each census block group were subtracted from the value for 2007 to compute the crime change in that time period. A quintile classification scheme was used to group the values into 1 of 5 groups based on these crime rates where the red values represent increases in crime during this time period. This quintile scheme makes each color or group represented the same number of times on a map and is used to counteract the effects that outliers may have on the data and subsequently the map. A higher scale map of the study area as well as surrounding block groups is highlighted in Map 4. Areas closer to downtown Durham have experienced major decreases in crime in this time period. This may be due to their location within the bulls-eye as part of 'Project Bulls-Eye', an initiative within Durham to focus on a 2-square mile portion of Durham that is generally considered as the epicenter for crime in the city. Through 'Project Bulls-Eye', a 31% decrease in crime within the bulls-eye helped yield Durham's lowest crimes rate in 10 years (Sharma 2011). Using the GIS analysis from this project, only 2 of 16 census block groups within the bulls-eye region experienced increases in crime during this time period. The boundary of this bulls-eye is shown in purple in Map 4.

While some of this news may be encouraging, an exploration of Part II crimes in the study area may yield other news for parts of the study area outside of the bulls-eye. By Querying and *Summarizing* Part II crimes that occur within the study area, one can explore the types of less serious/violent crimes that occur with an area that contribute to neighborhood safety and quality of life. Of note is that drug crimes increased from 202 in 2007 to 357 in 2010. For 2010, there were 16.5 incidents of vandalism (an indicator of gang activity) and 12.3 drug crimes per 1,000 people within the study area. By comparison, the rate for vandalism outside of study area was 9.7 per 1,000 and for drugs it was 4.5. This is not good news.

VI. GIS at North Carolina Central University

Data provided by the Durham Police Department, as well as other GIS data accrued at NCCU, are stored on a server dedicated for that purpose. Metadata is currently being developed. The use and application of this influx of crime data has taken students research in various directions. While NCCU has traditionally offered GIS coursework revolving around the earth and environmental sciences, students have begun working with this crime data as part of their coursework at NCCU. The DEEGS at NCCU offers an Introductory GIS (GEOG 3435) and Applied GIS (GEOG 4010) courses. Students have leeway about the types of project and research that they will present in front of their colleagues at the end of the semester. Some of the projects, which vary their depth of analysis because of the course, using this crime data include:

- Prostitution in Durham
- Visualization of DUI Arrests in Durham
- Homicide in Durham
- Exploring the relationship between DUI arrests and the location of ABC stores in Durham

VII. Discussion

The crime data provided signify those offenses reported by the Durham Police Department. These data represent a reflection of criminal activity in Durham processed

by the author. The Durham Police Department is in no way responsible for the quality of this analysis or the maps created from these analyses. Please contact the author with any questions about the analyzed data or maps.

In many cases, data preparation and the various forms of accuracy such as horizontal, temporal, attribute and semantic, must be addressed. The Durham Police Department graciously provided the data with their exact northing and easting, as well as attribute information that can be queried. In cases where personal privacy needed to be maintained for a crime (such as forcible rape), a random offset was applied to the northing and easting by the Durham Police Department beforehand. All other crime values are provided with a northing and easting to the nearest foot.

Care must be taken when determining an appropriate aggregation unit in which to display data. The aggregation unit used in this study is the census block group. It is within these block groups that various metrics are displayed in Maps 2 - 4. Given a goal of thematic choropleth maps such as these is to highlight regional differentiation, the use of different scale units which may show different patterns may tell completely contradictory stories. Openshaw (1984) coined this term as the 'Modifiable Areal Unit Problem' (MAUP). For example, there may be a cluster of high crime at the census block group level that can be detected. However, these blocks may lie in different census tracts and their rates' interactions other census block groups within the same tract may obfuscate these high values and more importantly this cluster. It is important that issues of MAUP be addressed by using a scale that adequately dictates and explains transparency between results rendered at various scales. In looking at crime density at different scales (block, block group, tract, zip code), they show the same general trends as highlighted in this research.

Lastly, the time intervals used in time-series analysis (2007 – 2010) and displayed in Map 4 merely show the general trends over this 4 year time period. If different intervals (2008 – 2009, for example) were used, they may show different trends. However, there are many different permutations of intervals that could be shown. As with the issues of MAUP, all efforts were taken to display transparency with these data. The interval shown in Map 4 was used because it encompassed all data from both a spatial and time aspect. Please contact the author if you wish to view or see data from other time periods besides those shown.

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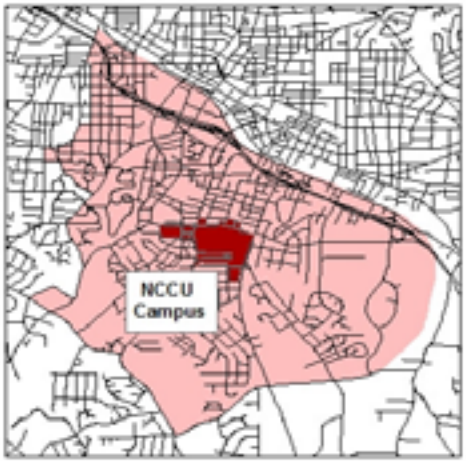
Map 1: Location of Durham

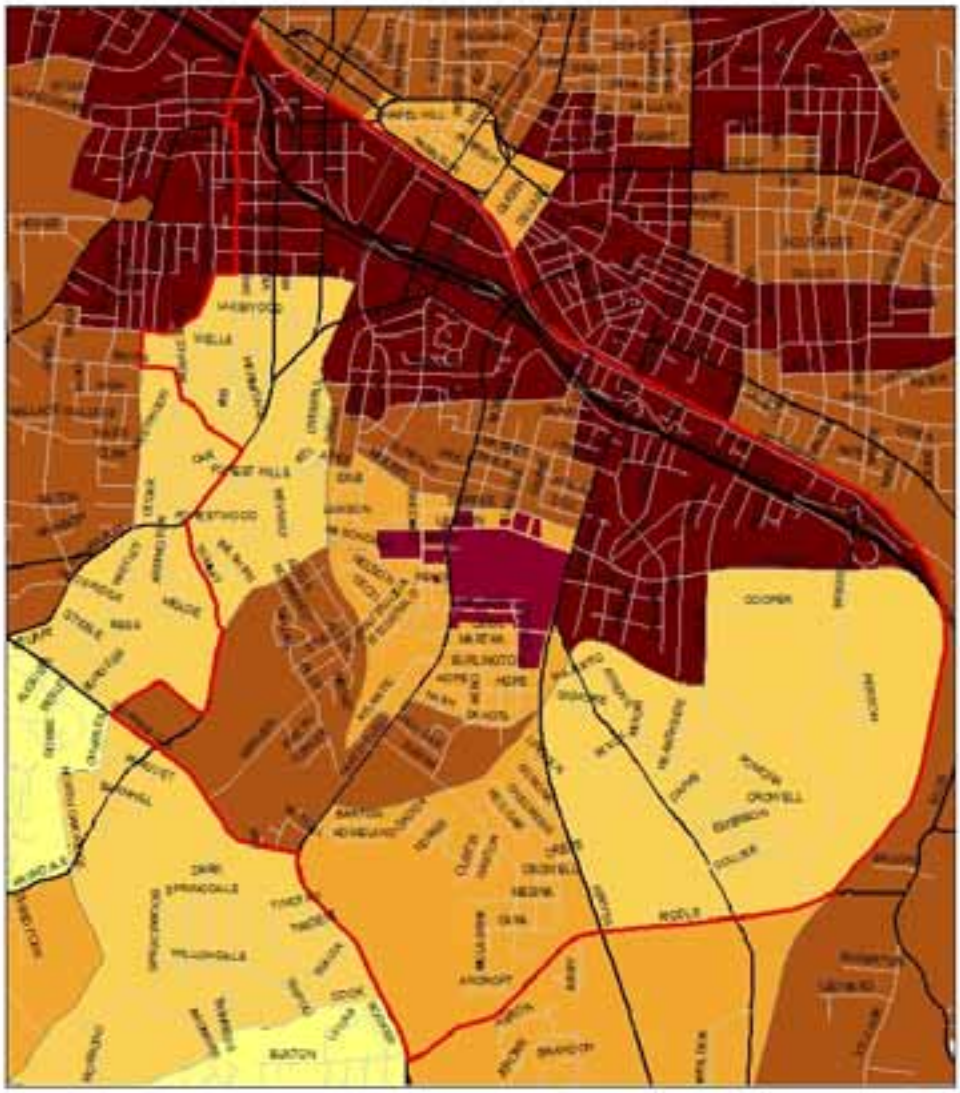
This map was created by the Geospatial Research, Innovative Teaching and Service Center (GRITS) at North Carolina Central University.

Not all data layers represented maintain the same accuracy level, therefore the map scale applied does not necessarily equate to the implied horizontal and vertical positional accuracy.

Source(s): City of Durham, ESRI



Map 2: Home Ownership
Percentage of People that Own Their Homes



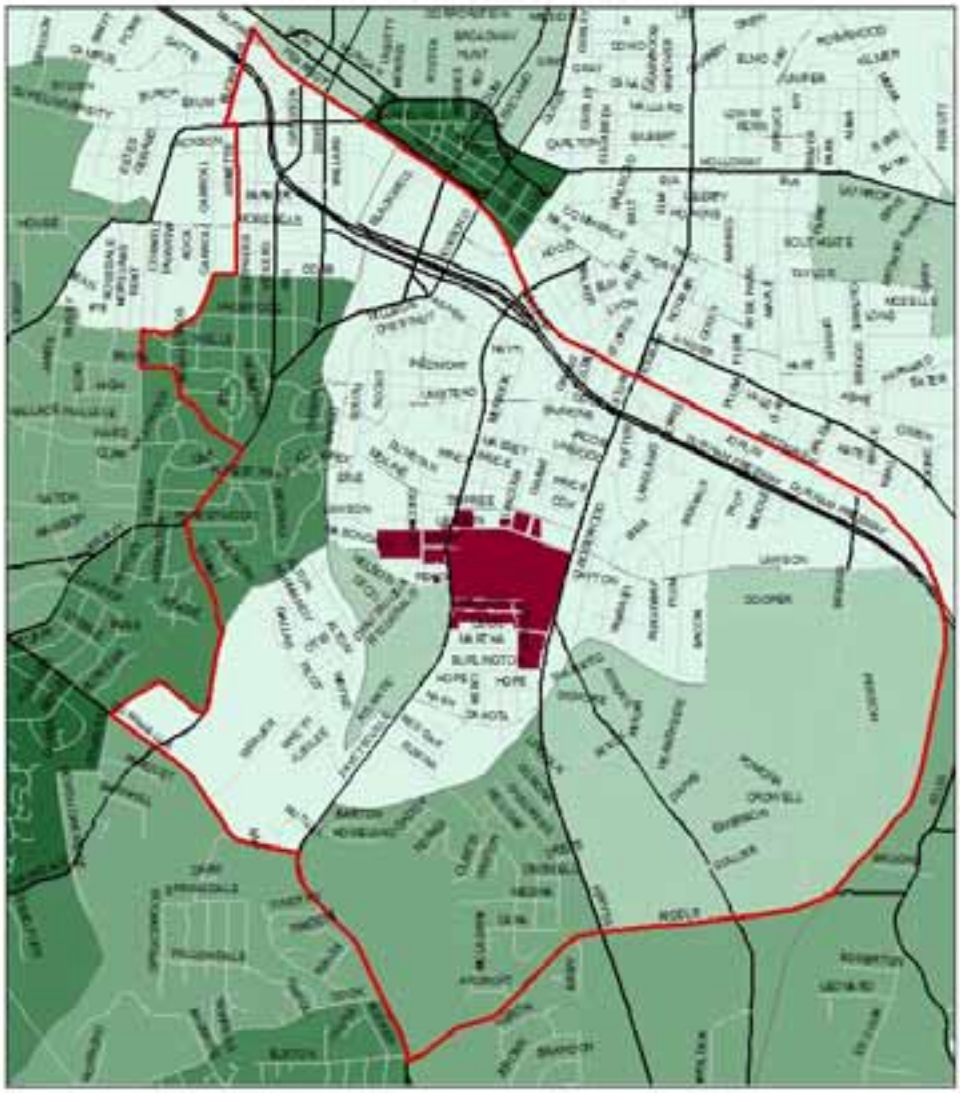
0 0.3 0.6 1.2 Miles

0 1,700 3,400 6,800 Feet

Rental %

- 2.4% - 14.91%
- 14.92% - 29.85%
- 29.86% - 56.21%
- 56.22% - 76.8%
- 76.81% - 100%

Map 3
Median Household Income



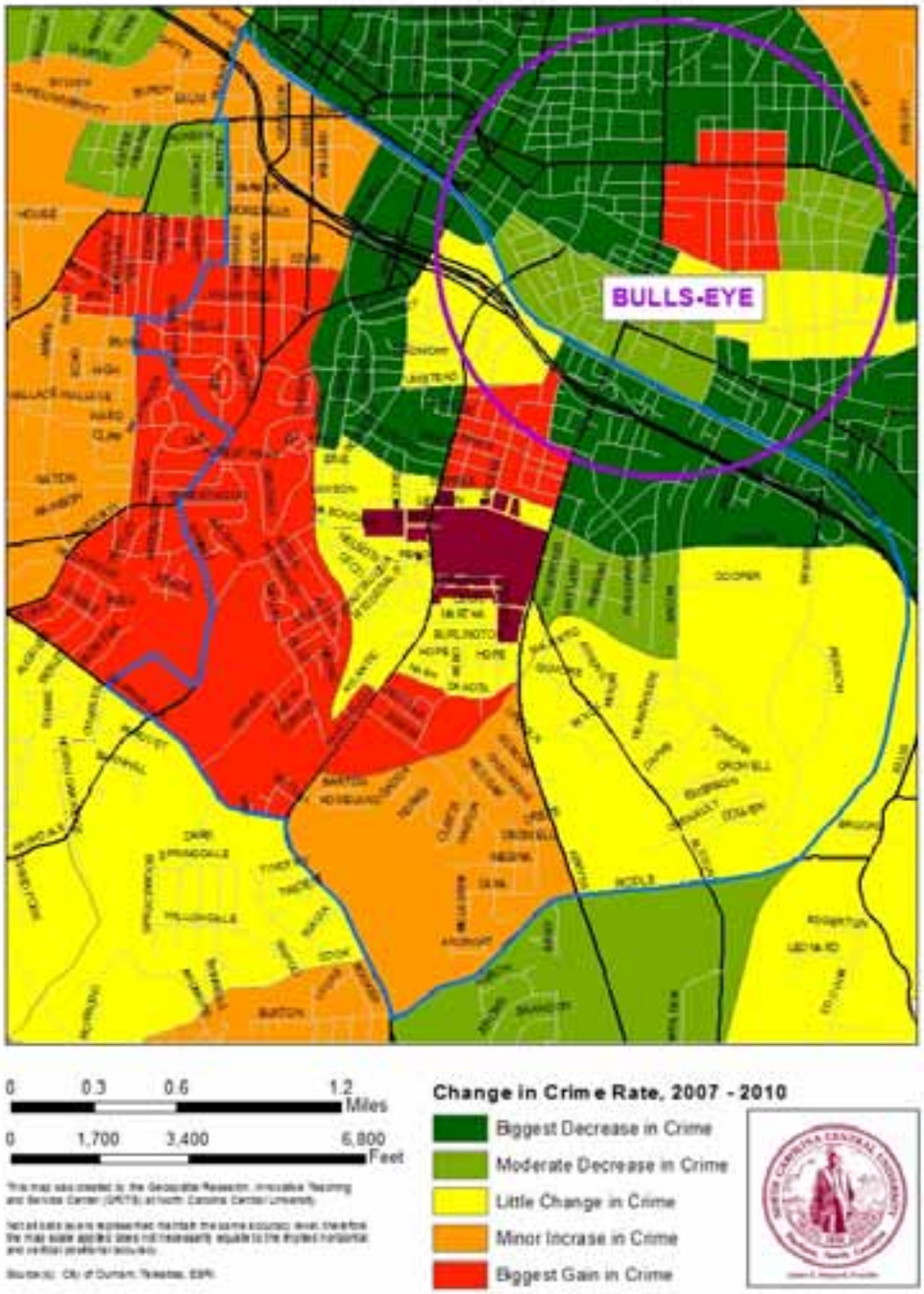
0 0.3 0.6 1.2 Miles

0 1,700 3,400 6,800 Feet

2009 Median HH Income

- $5,962.00 - $33,598.00
- $33,598.01 - $51,776.00
- $51,776.01 - $62,363.00
- $62,363.01 - $76,357.00
- $76,357.01 - $218,576.00

Map 4
Part I Crime Change, 2007 - 2010



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