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Assessing Foreclosure and Crime at Street Segments in Mecklenburg County, North Carolina

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ASSESSING FORECLOSURE AND CRIME AT STREET SEGMENTS IN MECKLENBURG COUNTY, NORTH CAROLINA

by

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Submitted in Partial Fulfillment of the Requirements for the
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Foreclosures are potentially problematic for neighborhood crime rates by providing crime attractors to residential communities. In the past, like many criminogenic features, foreclosures were typically seen as an inner city problem; however, in the wake of the housing market collapse of 2008 precipitated by suspect banking practices, foreclosures were particularly impacting young and new middle class homeowners (i.e., people with little credit history or assets). This study improves upon past research in two areas. First, instead of using large heterogeneous units of analysis (e.g., block groups, tracts, counties), this study uses street blocks. Street blocks, here, are preferred because of their relative homogeneity, especially when compared to large aggregate areal units. Second, this study restricts crime to only those that occur in residential areas. The routine activities surrounding residential areas are substantially different from those surrounding other land uses. Chi-square results show a significant and positive relationship between foreclosure and crime. Moran's I shows a significant positive relationship between foreclosure and crime. LISA analysis additionally provides insight into the importance of locational characteristics that may further shed light on the foreclosure-crime relationship. Results here suggest further research of the foreclosure-crime relationship should utilize street segments as the base unit of analysis and control for crime location.

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CHAPTER 1

INTRODUCTION

The geography of crime has long provided scholars with noticeable spatial patterns, from the early 19th century crime maps produced by Andre-Michel Guerry and Adolphe Quetelet (Friendly, 2007) to the contributions of Shaw and McKay (1929). These studies rudimentarily established the non-randomness of crime across space. These systems of mapping have been greatly improved upon with the advent of computerized databases and global information systems (GIS) software. Researchers can now synthesize much greater amounts of data in a fraction of the time, which in turn allows for the analysis of much smaller areal units. Aggregation into large areal units can distort underlying patterns, which Openshaw (1981) termed the modifiable areal unit problem. However, some level of aggregation is required in order to provide relevant social context. Taylor (1995) suggests a particularly useful social construct is the street block (i.e., all addresses between two intersections or an intersection and a street's end). LeBeau (2000) and Weisburd and colleagues (2004) show the practical utility of the street segments. Specifically, at the street segment level, high crime street segments often are near low- or no-crime street segments. Lower resolution areal units (e.g., block groups, census tracts, counties) cannot provide enough detail to determine whether high crime counts persist throughout the areal unit or if certain subsections may be the primary crime generators while other subsections remain crime free.

Opportunity theories provide a framework through which the spatial proximity of high and low crime segments is explained. Environmental criminology (Brantingham & Brantingham, 1981) suggests the built environment distributes opportunities for crime

differentially across the urban landscape. Certain features (e.g., transportation nodes, bars) bring people together in time and space. According to routine activities theory (Cohen & Felson, 1979), crimes occur when motivated offenders and suitable targets converge in time and space in the absence of capable guardianship. Thus, places that facilitate the convergence of people increase the likelihood of a crime incident. Brantingham and Brantingham (1995), later revised by Kinney, Brantingham, Wuschke, Kirk, and Brantingham (2008), identify three place categories relating to crime: crime generators, crime attractors, and crime detractors. In this typology, crime generators are locations that bring people together in time and space, increasing opportunity (e.g., malls, entertainment areas, sporting venues). Crime attractors differ in that they attract "intending offenders" (Brantingham & Brantingham, 1995, p. 8), or motivated offenders with intent to commit an illegal or delinquent act, due to locational characteristics or activities (e.g., bars, drug and prostitution markets). Crime detractors are locations that discourage crime because they push people away (e.g., police stations).

As the landscape changes in form and function, places can transition between these categories (Kinney et al., 2008). Often, neighborhoods comprised of single family detached dwellings act as crime detractors for many crimes; they provide low densities of opportunity (as compared to multi-family dwellings or commercial districts) and a high level of guardianship, especially in areas of high owner occupancy because homeowners have a strong commitment to protecting the area and their property values (i.e., if crime were to increase in a neighborhood, properties would become less attractive to perspective buyers and, subsequently, property values could decrease). However, as economic conditions shift (e.g., primary industry leaves), so too does the

overall demand for housing and the wealth of individuals who now demand this housing. Previous research has shown that both places (see Blau & Blau, 1982; Sampson et al., 1997) and people (see Slocum, 2005) with lower socioeconomic statuses show high rates or propensities, respectively, for crime.

Prior to the housing market crash of 2008, foreclosure clustering was typified as a function of changes in the urban structure. Improvements in public transit (e.g., light rail lines), construction of the interstate highway system and increases in automobile durability that greatly reduced personal transportation costs have resulted in concentric zone model of urban growth (Burgess, 1925) and sector theory (Hoyt, 1939); this allowed residents to move from densely populated urban neighborhoods in favor of suburban communities (concentric zone) and wealthy enclaves (sector theory). The new residents to these neighborhoods did not possess the level of wealth that the former residents possessed, making the new residents more vulnerable to foreclosure. Thus, foreclosures under this process resulted from larger shifts in the urban mosaic.

The most recent foreclosure pattern departs from this by traditional pattern which frames economic struggles as primarily an inner city problem (i.e., foreclosure as a problem of divested inner city neighborhoods). Foreclosures following the 2008 housing market crash not only affected poor inner city neighborhoods, but also new and developing suburban communities and stemming from subprime mortgage lending practices (see Bess, 2008). These foreclosures induce a disruption not often associated with middle class suburban neighborhoods. Kingsley et al. (2009) provides a scenario of decay that may result from a housing foreclosure:

> After receiving a notice of foreclosures, the original owner may defer maintenance to try to keep up with payments. After the foreclosure, the home may remain vacant for a period of time with no one keeping it secured and well maintained while it is vacant. A high concentration of foreclosure sales in an area will lower comparables and knowledge of them may diminish lender confidence (p. 15).

Foreclosures forces residents unable to make mortgage payments out of their homes leaving a once occupied structure vacant. A lack of supervision at these abandoned places eliminates guardianship of the vacated structure and reduces overall neighborhood-level guardianship. Intending offenders seeking havens for illicit activities may find refuge in these structures abandoned through foreclosure. Thus, in terms of environmental criminology, an unoccupied house may transition between a crime detractor to a crime attractor. During these periods of vacancy, abandoned or unoccupied properties can be used as refuges for squatters or drug users; vacant homes have also been targets for crime (e.g., graffiti, scrap metal theft). These vagrant uses and victimization can cause further degradation to the property, impeding future sales of the property and perpetuating vacancy (Kingsley et al., 2009, p. 16). Under this scenario, a foreclosure begins a process by which guardianship is removed from a single family detached dwelling. Subsequently, the dwelling is a staging place for and victimized by multiple criminal acts. This hypothetical situation demonstrates how foreclosure might result in unguarded opportunities for motivated offenders. The recent housing market crisis provides an opportunity to advance the understanding of the relationship between foreclosure and crime.

As previously alluded, the foreclosure-crime relationship can be inferred through abandonment, one of the potential outcomes of foreclosure. This link between abandoned buildings and crime has long been understood; Spelman (1993) found 20 out of 24 unsecured abandoned buildings (i.e., those without proper locks and boarded windows) in one Austin, Texas neighborhood had signs of illegal activities, including drug use, prostitution, and storage of stolen property. It should be noted that for many of these vacant buildings, attempts had been made to secure the premises; however, the locks and plywood that had been used had been tampered with by people wanting to use the unsupervised space. Spelman and Eck (1988) found that unsecured and unusable apartments were used as hangouts for youths, from which criminal acts (e.g., burglarization of nearby occupied units) were staged. Not every foreclosure results in abandonment. Although, as Kingsley and colleagues (2009) note, spatially concentrated foreclosures are more likely to result in previously occupied houses remaining vacant for long periods of time. Conversely stated, wealthy blocks that experience a single foreclosure may experience a slight disturbance, such as a small reduction in housing values (Immergluck & Smith, 2006b); however, without subsequent foreclosures, the neighborhood should recover quickly. Spatially concentrated foreclosures (rather than isolated singular foreclosures) are expected to have the greatest effect on neighborhood crime (i.e., neighborhoods would be less likely to recover from multiple foreclosures rather than a single foreclosure). Therefore, a distinction must be made between random, isolated foreclosures and clustered foreclosures.

In particular, this study aims to test the relationship between number of residential properties that had been foreclosed and crime, each measured at the street segment level, in Mecklenburg County, North Carolina using data around the 2008 housing market crash in the United States. For the present study, the number of foreclosed properties (rather than foreclosure rate) was most appropriate because I aim to explain the foreclosure-crime relationship through routine activities and crime pattern theories. In this framework, each additional foreclosed property provides an additional opportunity for crime to increase on the street segment. In particular, in areas of concentrated foreclosure, I expect to find a direct relationship between foreclosure and crime.

This study progresses the literature on crime and foreclosure from three perspectives. First, this study measures both crime and foreclosure at micro-geographies or small areal units (e.g., street block, intersection area), a current gap in the literature. By examining crime and foreclosure at small areal units of analysis (i.e., the street segment), this study assesses differences between no foreclosure, sparse foreclosure, and densely clustered foreclosure and crime. Secondly, by restricting crime place to residential locations, the correlation between crime and foreclosure can be more appropriately assessed. Predominantly, foreclosures impact residential neighborhoods and, therefore, crime must be measured accordingly. Thirdly, regionalization of the foreclosure-crime relationship can be assessed using Moran's I and local indicators of spatial association.

CHAPTER 2

REVIEW OF THE LITERATURE

Effects of Foreclosure

The economic impact of foreclosures has been well established; studies show a single foreclosed house can decrease the value of neighboring properties by as much as 8.7 percent, most probably due to eroding lender and consumer confidence in and around foreclosed houses (Pennington-Cross, 2004; Immergluck & Smith, 2005; Immergluck & Smith, 2006a; Lee, 2008). However, this same certainty has not been granted to the effects between foreclosure and crime, potentially because of a reliance on large areal units when aggregating crime and foreclosure measures.

Studies have generally found some support for a positive crime and foreclosure correlation. Table 1 shows nine studies published in peer-reviewed journals and one dissertation since 2006 that assess crime and foreclosure since 2006. From these results, a general positive relationship between crime and foreclosure can be inferred, with more significant positive significant results (19) than significant negative results (5) across all crime types; however, these results are far from conclusive with 16 non-significant findings. These inconsistent findings could be resultant from one of two methodological issues. First, the inconsistent findings could be the result of relying upon large areal units of aggregation. These units of analysis include counties (Goodstein & Lee, 2010; Arnio et al., 2012), community areas (Kirk & Hyra, 2010), police beats (Harris, 2011), census tracts (Immergluck & Smith, 2006b; Teasdale et al., 2011; Arnio & Baumer, 2012), and block groups (Katz et al., 2011). Some of these units of analysis are large, heterogeneous areas. If, for example, crimes and foreclosures

were occurring in different parts of a county, a relationship found between crime and foreclosure would be spurious. The modifiable areal unit problem (MAUP) (Openshaw, 1981) suggests aggregation to larger areal units has the potential to mask underlying relationships. That is, the underlying relationship is often stronger than results would suggest when measured at larger areal units (Andresen & Malleson, 2011). Therefore, smaller, more homogenous units of analysis (e.g., street segments) may more accurately assess the foreclosure-crime relationship.

Table 1

Studies that assess the crime-foreclosure relationship with regression analysis

Author(s)	Study Area	Unit of Analysis	Crime - Foreclosure Relationship				Crime Types*
			All Crime	Property Crimes	Violent Crimes	Public Order	
Immergluck & Smith (2006)	Chicago, IL	Census Tracts	+	-	+		Total Crime; Property Crime; Violent Crime
Cui (2010)	Pittsburgh, PA	Buffer + Control Areas		+	+		Property Crime; Violent Crime
Goodstein & Lee (2010)	United States	Counties		+ + + +	- - + + +		Property Crime; Larceny; Burglary; Motor Vehicle Theft; Violent Crime; Robbery; Aggravated Assault; Rape; Murder
Kirk & Hyra (2010)	Chicago, IL	Community Areas		- + o	+ +		Property Crime; Burglary; Theft; Violent Crime; Robbery
Harris (2011)	Houston, TX	Police Beats	+	+ - -	- - +		Total Crime; Burglary; Theft; Motor Vehicle Theft; Murder; Robbery; Aggravated Assault
Katz et al (2011)	Glendale, AZ	Block Groups	+	+	+	-	Total CFS**; Property Related CFS; Violence-Related CFS; Drug Related CFS
Teasdale et al (2011)	Akron, OH	Census Tracts		+ +		+ + +	Larceny; Burglary; Drug Violations; Public Order Crimes; Disorderly Conduct
Arnio & Baumer (2012)	Chicago, IL	Census Tracts		+	+ +		Burglary; Homicide; Robbery
Arnio et al (2012)	United States	Counties		+	+		Burglary; Robbery

***+** = a significant positive finding, + = a non-significant positive finding, **-** = a significant negative finding, - = a non-significant negative finding, o = indeterminate result, *crimes listed in order moving in rows from left to right, **calls for service*

Second, a failure to control for crime place may be diluting the observed foreclosure-crime relationship in the aforementioned literature. Housing foreclosures, as previously mentioned, affect residential neighborhoods. Residential neighborhoods, especially if predominated by single family detached dwellings, are low opportunity areas; these areas do not draw transient populations, providing little or no land use opportunities for outsiders. Therefore, foreclosures and crime should display some level of disconnect, especially for crimes that require the convergence of people. For example, studies assessing foreclosure and robbery find both positive (Kirk & Hyra, 2010; Arnio & Baumer, 2012; Arnio et al., 2012) and negative (Goodstein & Lee, 2010; Harris, 2011) relationships. Alternatively, crimes affecting residential locations (e.g.,

burglary) show a consistent positive correlation between foreclosure and crime (Goodstein & Lee, 2010; Harris, 2011; Teasdale et al., 2012; Arnio & Baumer, 2012; Arnio et al., 2012).

Third, aggregation to large areal units does not measure foreclosure in enough detail needed to capture criminogenic effects. No study to date has assessed the distance decay effect foreclosure has on crime, so this relationship can only be inferred through research on how foreclosure impacts nearby property values. Studies find that property value does decrease when a nearby property is foreclosed (Lee et al., 2009); however, this devaluation effect is highly localized. Past research shows that this devaluation effect may be captured at the street segment level. For example, Lee and colleagues (2009) found the strongest devaluation effects occurred within 300 feet of a foreclosure with negligible effects on properties beyond 2900 feet; Immergluck and Smith (2006a) found the strongest devaluation effect on properties within 660 feet of a foreclosure. These results suggest the ill-effects caused by foreclosures do not extend out across large areas. Instead, any adverse effects caused by foreclosure are strongest on the block on which they occur and nearby blocks feel a reduced impact. This same pattern may also be present in the foreclosure-crime relationship. By using large areal units for analysis the underlying correlation between foreclosure and crime is masked (i.e., the effect of foreclosure on crime is localized as well).

The proposed study attempts to overcome these obstacles by using a (nearly) homogenous unit of analysis and abandoning the use of foreclosure rates in favor of spatio-temporal clustering of housing foreclosures. Specifically, foreclosures and crimes are aggregated to street segments for Mecklenburg County, North Carolina in

order to test how these phenomena covary in space. At this unit of analysis, differentiation can be made between segments with no, sporadic, and concentrated foreclosures. By assessing the foreclosure-crime relationship in this manner, substantial intra-county differences emerge.

CHAPTER 3

DATA AND METHODS

Data

Data for this study are provided by Charlotte-Mecklenburg Police Department (CMPD). CMPD's jurisdiction includes all of Mecklenburg County, North Carolina, a majority of which is contained within Charlotte city limits as well as a few outlying areas (Cornelius, Davidson, Huntersville, Matthews, Mint Hill, and Pineville) (see Figure 1). Mecklenburg County has a population of 919,628 people, of which 731,424 (79.5 percent) people live within Charlotte city limits (US 2010 Census). According to the United States 2010 Census, Charlotte ranks as the 17th largest city in the United States.

Crime data include crime incidents at residential addresses (hereafter referred to as crimes) between 1 January 2005 and 31 December 2010 (N =310,280) in Mecklenburg County. CMPD provided crime data as either coordinate pairs or addresses and recorded according to the National Incident-Based Recordings System (NIBRS).Crimes are excluded based upon two factors: 1) crimes recorded at the location of the report rather than the incident location (n=10,677, 3.4 percent), and 2) crimes recorded without a coordinate pair and a street number (n=33,341, 10.1 percent). Without these two pieces of information, the exact location of the crime cannot be determined. This yields 266,262 crimes with full information recorded at the location of their incidence. Of these crimes with full information recorded at the location of incidence, 2,553 (1.0 percent) failed to geocode. Geocoding failure here appears to be random; therefore, this random loss of data is well within the acceptable limit of up to

15 percent random attrition (Ratcliffe, 2004). The final useable dataset includes 263,709 crimes.

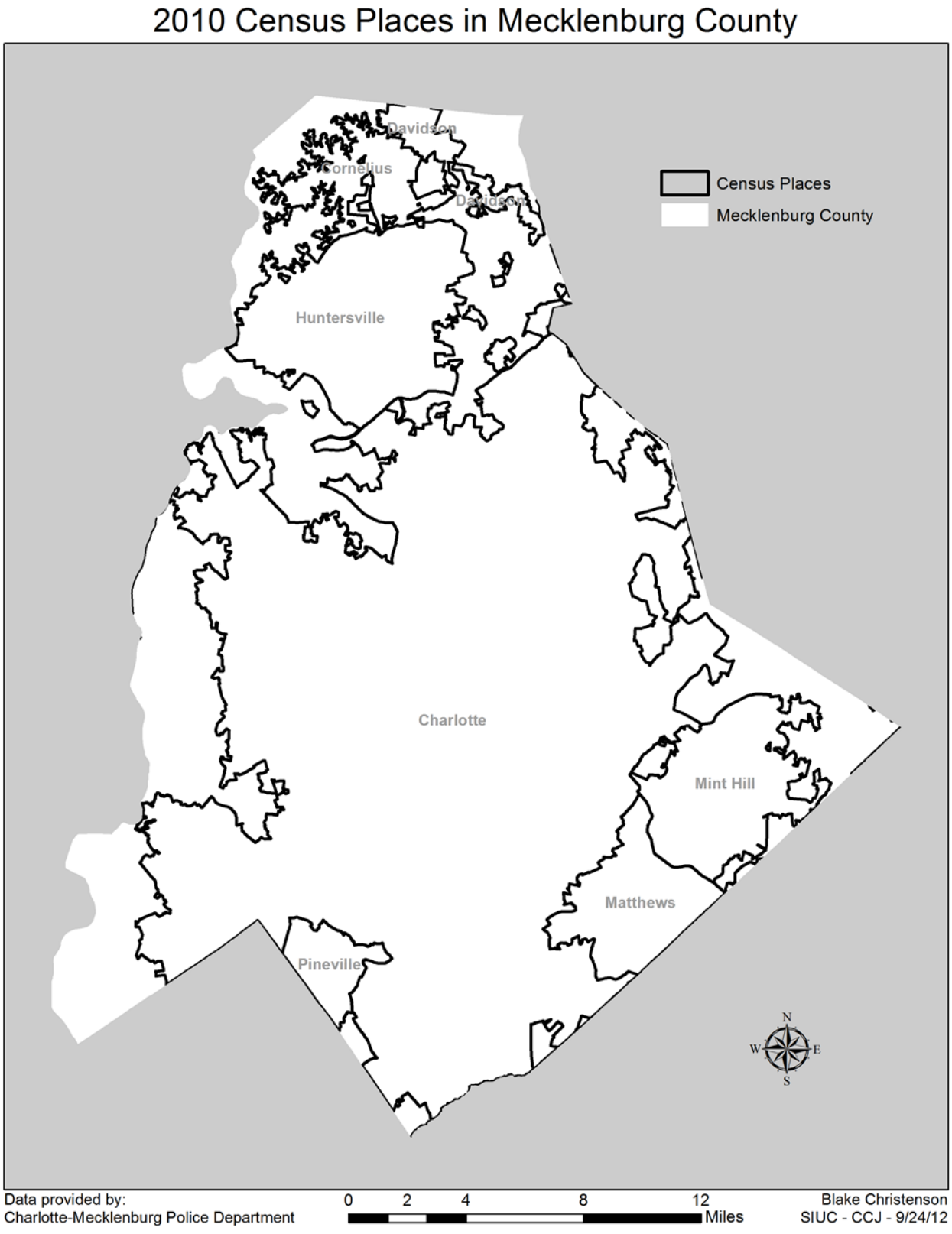

Figure 1. Census Designated Places in Mecklenburg County

Housing foreclosures are measured between 1 January 2004 and 31 December 2009 (N = 16,047). The foreclosure measure lags one year behind crime data, methodology similar to other studies examining the crime-foreclosure relationship (Goodstein and Lee 2010; Kirk and Hyra, 2011; Arnio et al, 2012). For this study, a foreclosure is defined as a foreclosure filing at a residential property, including: single family dwellings, duplexes, multiplexes, apartments, and condominiums. Any particular property may have been foreclosed multiple times during the study period; however, in the data only the most recent foreclosure filing is recorded. Therefore, foreclosure here measures prevalence by property during the study period.

The unit of analysis for this study is the street segment. Taylor (1997) identifies this as an important construct in urban space when understanding the pattern of crime in space; the street segment level allows researchers to capture within-neighborhood fluctuation in social conditions (i.e., street segments are socially more homogeneous than block groups or tracts). This is particularly important given recent research showing the stability in crime concentrations over time when measured at the street segment-level (Weisburd et al, 2004; Braga et al, 2010).

The total street segment count in Mecklenburg County is 34,465 street segments with an average segment length of 611 feet (standard deviation = 624 feet). The median street length is 438 feet. Importantly, the mean and median street lengths are within the aforementioned devaluation effect window (300 feet to 660 feet) of foreclosures on property values. Therefore, the street segment, as a unit of analysis, is capable of capturing the nuanced impact of foreclosures.

Measures

In order to analyze crime and foreclosure at street segments, these data must be transformed. First, crimes are broken into yearly intervals (1 January to 31 December). Then, each year's worth of crimes is aggregated to street segments using ArcGIS 10.0 using a point-on-line procedure (LeBeau, 2000, p. 5). This generates a six year "crime profile" for each segment. Further, group-based trajectory modeling (GBTM) (Nagin and Land, 1993; Nagin, 2005) is used to generalize these crime profiles into a finite number of groups by statistically establishing general trends in the data. Segments with similar crime profiles are aggregated to form groups; tendencies for the group can then be established once group membership is determined.

A criticism of GBTM is the over specification of groups established and therefore the number of groups established by GBTM should be constrained (Sampson and Laub, 2005). Eggleston and colleagues (2004) found over specification to be particularly problematic as the number of observations increased. Nagin and Odgers (2010) further suggest attempts to restrict the total number of groups could help strengthen analysis. Given the number of street segments included for analysis here, relying solely upon the Bayesian information criterion (BIC) would result in over specification. Accordingly, other controls are included to constrict the number of groups given the large sample size in this study. The criteria used include: percent change in the BIC, average posterior group probability, minimum single group average posterior probability, and minimum group count.

Table 2 displays the results for each of these model specification measures with the chosen four group model emphasized in bold text. From these measures, a four

group model is chosen because the percent change in the BIC is above 5 percent (6.56 percent), the minimum average posterior probability for group membership is above 0.95 (i.e., there was an over 95 percent chance that segments assigned to each group were properly specified), and the minimum group membership count is above 1 percent (585 segment or 1.70 percent of segments).

Table 2

Group-based trajectory modeling diagnostics

# of Groups	BIC	% Change in BIC	Avg Post Prob	Minimum Post Prob	Maximum Post Prob	Minimum Group N	Percent of All Segments
2	-280447.1		98.19%	97.77%	98.60%	2072	6.01%
3	-252977.2	9.80%	97.63%	95.50%	99.06%	1071	3.11%
4	**-236372.5**	**6.56%**	**96.45%**	**94.16%**	**98.56%**	**585**	**1.70%**
5	-230096.8	2.66%	94.76%	92.11%	98.67%	312	0.91%
6	-226749.1	1.45%	94.64%	89.42%	99.16%	160	0.46%

Foreclosures are also aggregated to street segments following the point-on-line procedure (LeBeau, 2000, p. 5). Based upon the prior research on the economic impact of foreclosure and the criminogenic effects predicted through crime pattern theory, segments with no, sporadic, and concentrated foreclosure are expected to differ substantially from the ill-effects of foreclosure. First, the probability of vacancy should be higher on segments with high foreclosure counts as compared to no or low foreclosure counts. Secondly, each additional vacancy incrementally increases opportunity for intending offenders. Accordingly, three levels of foreclosure at street segments are considered: no (0) foreclosure problem, a moderate (1-2) foreclosure problem, and a large (3+) foreclosure problem between 2004-2009.

Descriptive Statistics: Crime

During the six year study period crime counts in residential areas average 43,951.5 annually, with a high of 46,335 crimes in 2007 and a low of 38,205 crimes in 2010 (see Figure 2). A breakdown of each crime type and each crime type's percent of total crime are shown in Table 3. Burglaries and theft from motor vehicles account for almost one-third (30.31 percent) of crime and adding vandalism and simple assaults accounts for over half (50.61 percent) of all crime during the study period.

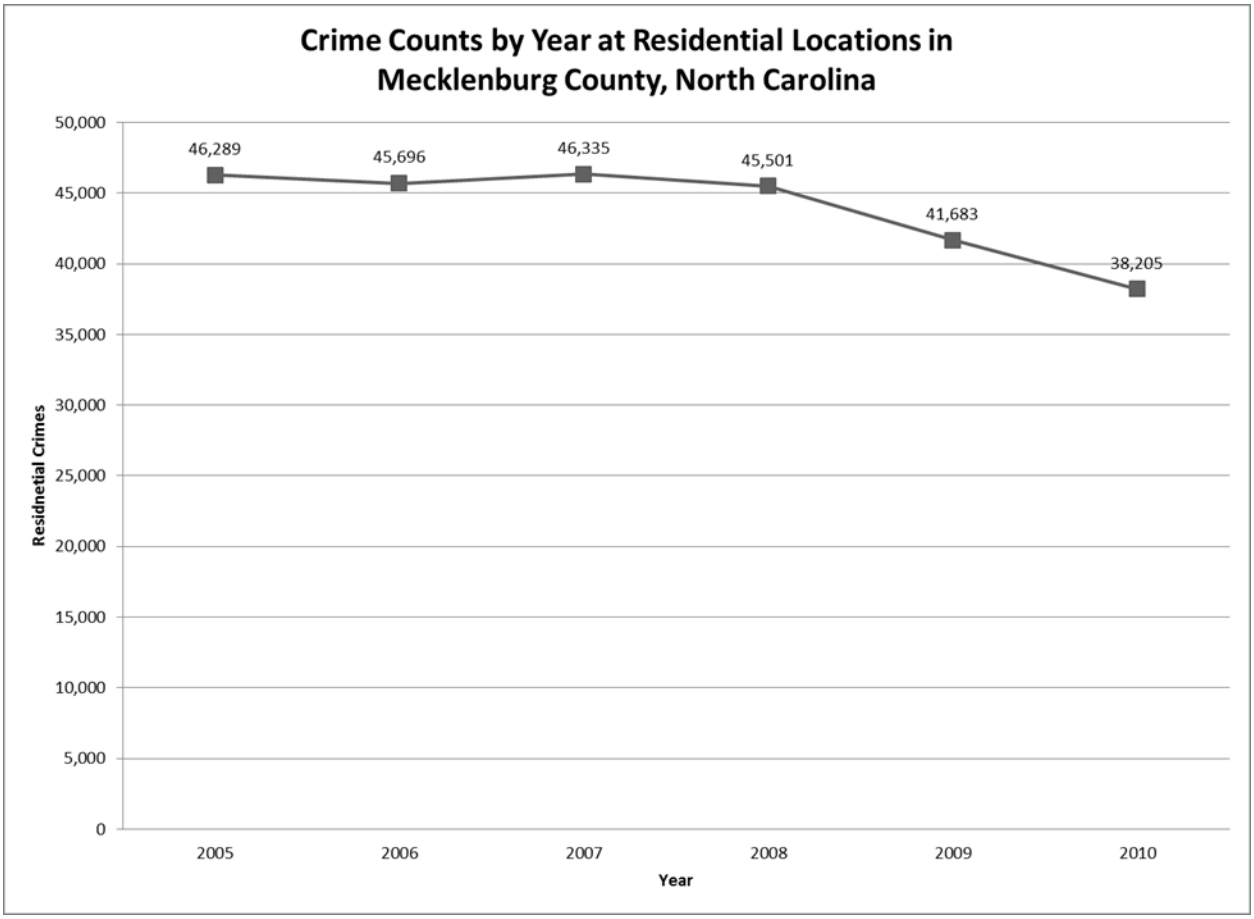

Figure 2. Residential Crime Counts by Year

Table 3

Frequency distribution for crimes that occurred at residential addresses in Mecklenburg County, North Carolina (2005-2010)

Rank	Crime Classification	Total Count	Percent of Total	Cumulative Percent
1	Burglary/B&E	47,471	18.00%	18.00%
2	Theft from Motor Vehicle	32,461	12.31%	30.31%
3	Damage/Vandalism of Property	28,793	10.92%	41.23%
4	Simple Assault	24,751	9.39%	50.61%
5	All Other Thefts	22,069	8.37%	58.98%
6	Motor Vehicle Theft	19,892	7.54%	66.53%
7	Intimidation	12,096	4.59%	71.11%
8	Aggravated Assault	7,329	2.78%	73.89%
9	Missing Person	6,785	2.57%	76.47%
10	Robbery	5,044	1.91%	78.38%
11	Drug/Narcotic Violations	4,296	1.63%	80.01%
12	Theft of Motor Vehicle Parts from Vehicle	3,952	1.50%	81.51%
13	Impersonation	3,199	1.21%	82.72%
14	Theft from Building	2,988	1.13%	83.85%
15	All Other Offenses	42,583	16.15%	100.00%
	Total	263,709	100.00%	100.00%

As previously mentioned GBTM statistically establishes segments into groups with similar crime profiles. Based upon various aforementioned model fit criteria, the four group model is the best match for the data. These four groups are labeled, from most crime to least crime: 1) “high crime”, 2) “medium crime”, 3) “low crime”, and 4) “little/no crime” segments. The yearly average crime level for each group trajectory is shown in Figure 3. These group trend lines are not indicative of any street segment within the group per se; however, these figures are useful in order to understand a prototypical group member. Similar to the results presented in Weisburd et al (2004),

the data here suggest yearly fluctuations in incidents are primarily caused by changes in the high crime trajectory group(s) while other trajectory groups remain relatively stable across the study period.

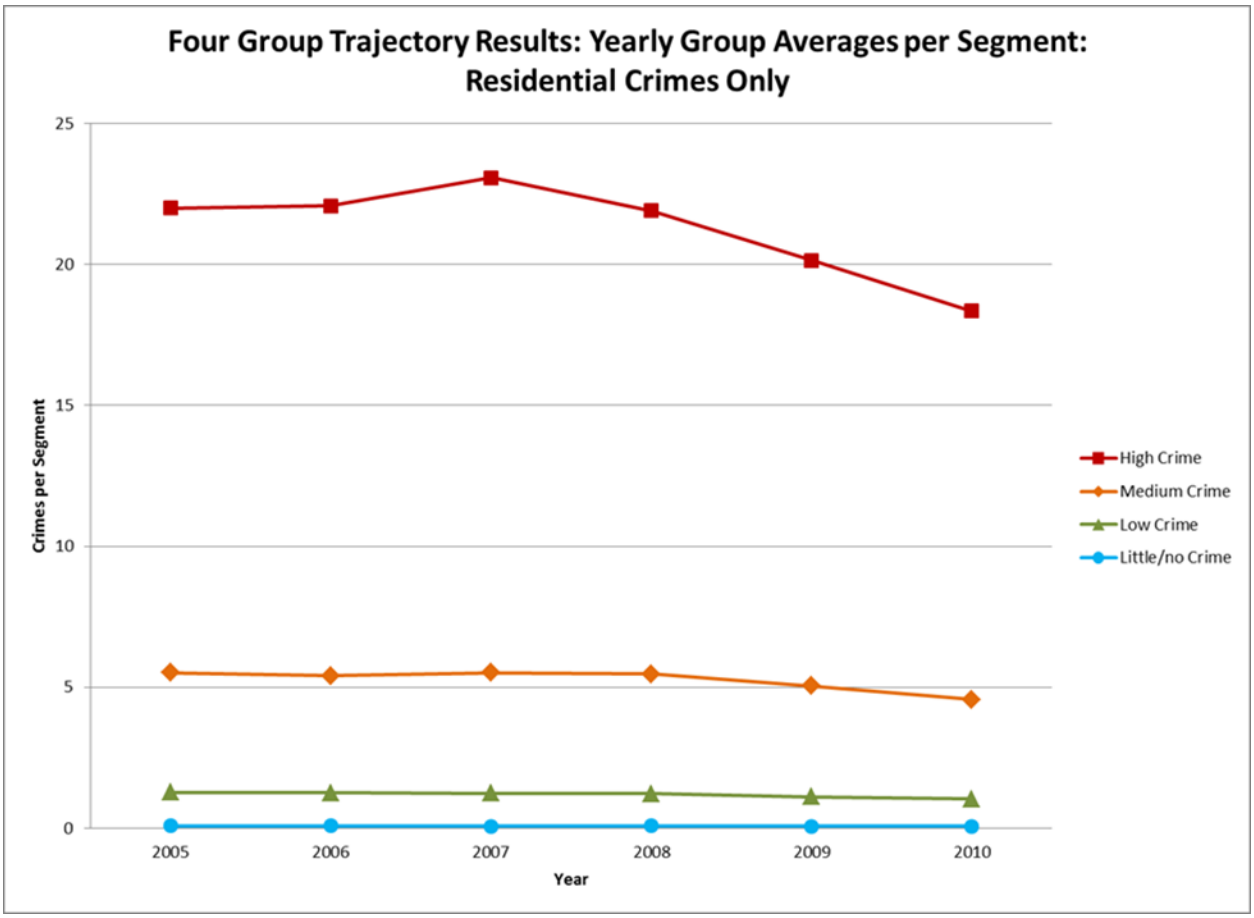

Figure 3. Average trajectories for four group model

Additionally, group averages are compared across all six years in the study period (Table 4). During the study period, high crime street segments account for 28.29 percent of crimes but only 1.70 percent of all segments averaging 21.251 crimes yearly. Medium crime segments account for 37.86 percent of crimes and 9.19 percent of all segments averaging 5.253 crimes yearly. Low crime segments account for 30.48 percent of crimes and 32.66 percent of all segments averaging 1.19 crimes yearly. Little/no crime segments account for 3.37 percent of crimes and 56.45 percent of all

segments averaging 0.076 crimes yearly.

Table 4

Group characteristics for a four group model (values reflect six year totals and yearly averages)

Group	Total Segments	% of All Segments	Total Crimes	% of All Crime	Avg Yearly Crimes per Segment	Median Yearly Crime Count	Standard Deviation	Minimum Yearly Crimes	Maximum Yearly Crimes
High Crime	585	1.70%	74,592	28.29%	21.251	17.833	10.395	4.000	81.333
Medium Crime	3,168	9.19%	99,850	37.86%	5.253	0.500	2.273	1.333	12.000
Low Crime	11,256	32.66%	80,382	30.48%	1.190	0.333	0.649	0.500	3.000
Little/No Crime	19,456	56.45%	8,885	3.37%	0.076	0.167	0.120	0.000	0.333
Total	34,465	100.00%	263,709	100.00%	1.275	0.167	3.391	0.000	81.333

Using similar methodology as Weisburd et al 2004, kernel density estimations (KDE) assess street segment trajectory group clustering across urban space. KDE estimates a density at each point of a distribution (here, the density of street segments of a particular trajectory group) per unit area using a set search radius. Values are then interpolated using a kernel smoothing algorithm in order to generate smoothed surfaces. These maps depict highly concentrated areas for each trajectory in increasingly darker colors. Concentrated areas for any particular trajectory can then be identified. Here, a search radius of 2,979 feet is used for all KDEs; a circle with a radius of 2,979 feet has an area equal to one square mile. Value ranges are then set at interval of 25 segments per square mile in order to compare across trajectory group and foreclosure KDEs.

Before assessing the KDEs for each crime grouping, the overall distribution of street segments in Mecklenburg County must be understood (see Figure 4). The average density of street segments across Mecklenburg County is 63 segments per square mile. However, the central city core of Charlotte, colloquially known as Uptown, the street segment density peaks between 325 and 350 segments per square mile.

Generally, this pattern shows a distance decay effect around Uptown in the street segment density (i.e., the density of street segments decreases as the distance from Uptown increases).

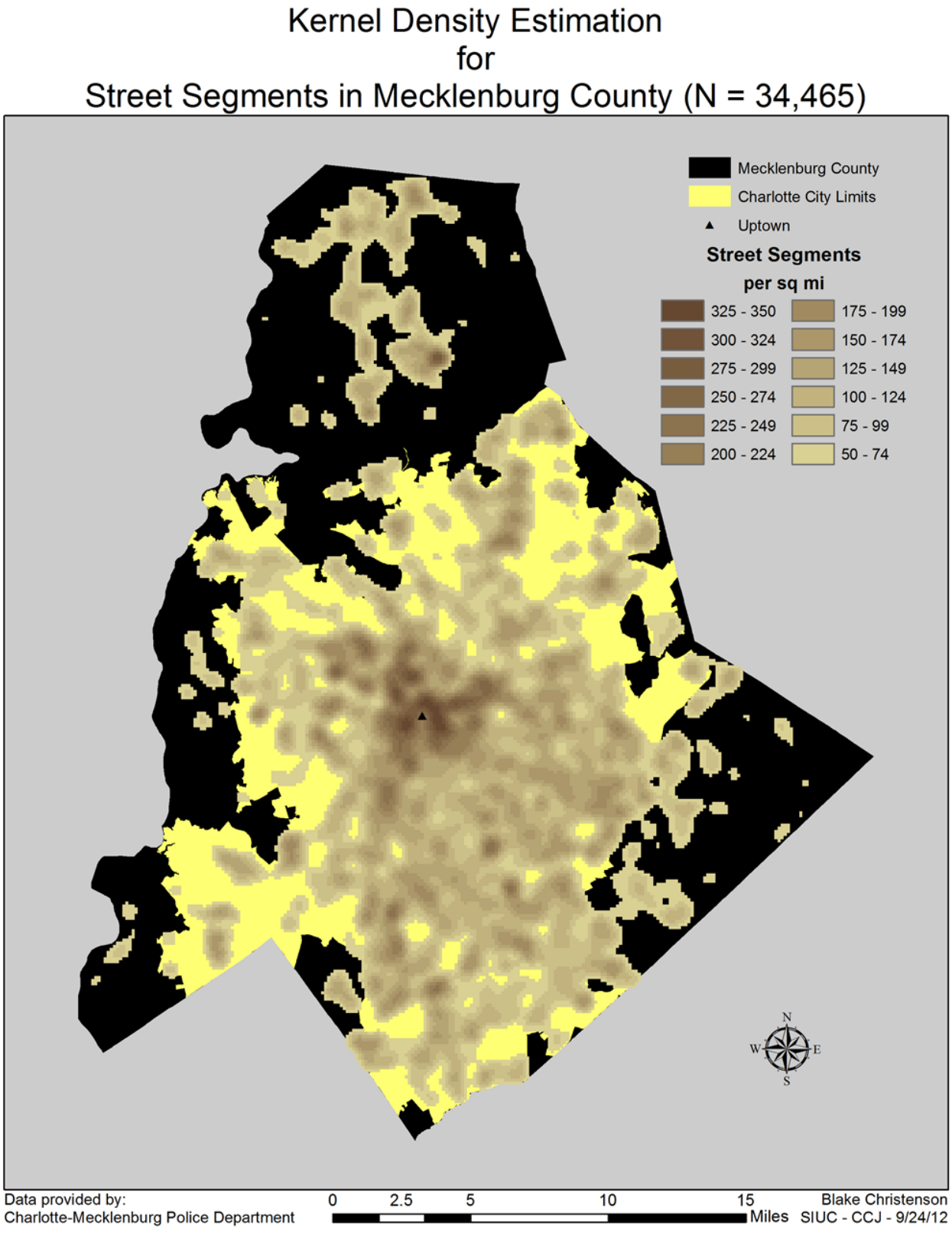

Figure 4. Kernel density estimation for street segments in Mecklenburg County

In comparison, the next four Figures (Figure 5 – Figure 8) show the distribution of high, medium, low, and little/no crime group segments. High crime segments are most dense in three distinct locations. Three locations eclipse the 25 high crime segments per square mile threshold; one concentration is about 4.5 miles west northwest and two concentrations are about 6.5 miles southwest of Uptown (see Figure 5). Notably, because this study only includes residential crimes, Uptown (i.e., Charlotte's central business district) does not register as the highest crime location. Instead, high crime segments concentrate well outside of the central city due to land use patterns (i.e., central business districts do not have, by definition, residential land uses). Medium crime segments concentrate closer to Uptown with a peak density between 50 and 75 segments per square mile with one concentration about 1 mile east of Uptown and three concentrations between 2 and 3 miles northwest of Uptown (see Figure 6). Low crime segments concentrate in areas about 1 to 2 miles surrounding Uptown and peak between 125 and 150 segments per square mile; some secondary concentration of low crime segments concentrate between 6 to 7 miles east of Uptown (see Figure 7). Lastly, little/no crime trajectory segments are most concentrated in and around Uptown, most likely because this area does not include any residential land uses. Also, some secondary concentrations of little/no crime trajectory segments occur in two general locations: 1) a wedge south of Uptown and 2) in the northernmost portion of Mecklenburg County (see Figure 8). Given that 56.45 percent of segment fall into the little/no crime group, the little/no crime group kernel density map is very similar to that of the overall segment pattern in Mecklenburg County. Notably, though, areas northwest

to east of Uptown at a radius of between 5 and 6 miles are (relatively) devoid of little/no crime trajectory segments with densities of less than 50 little/no crime segments per square mile (i.e., these segments are categorized in one of the three higher crime trajectory groups).

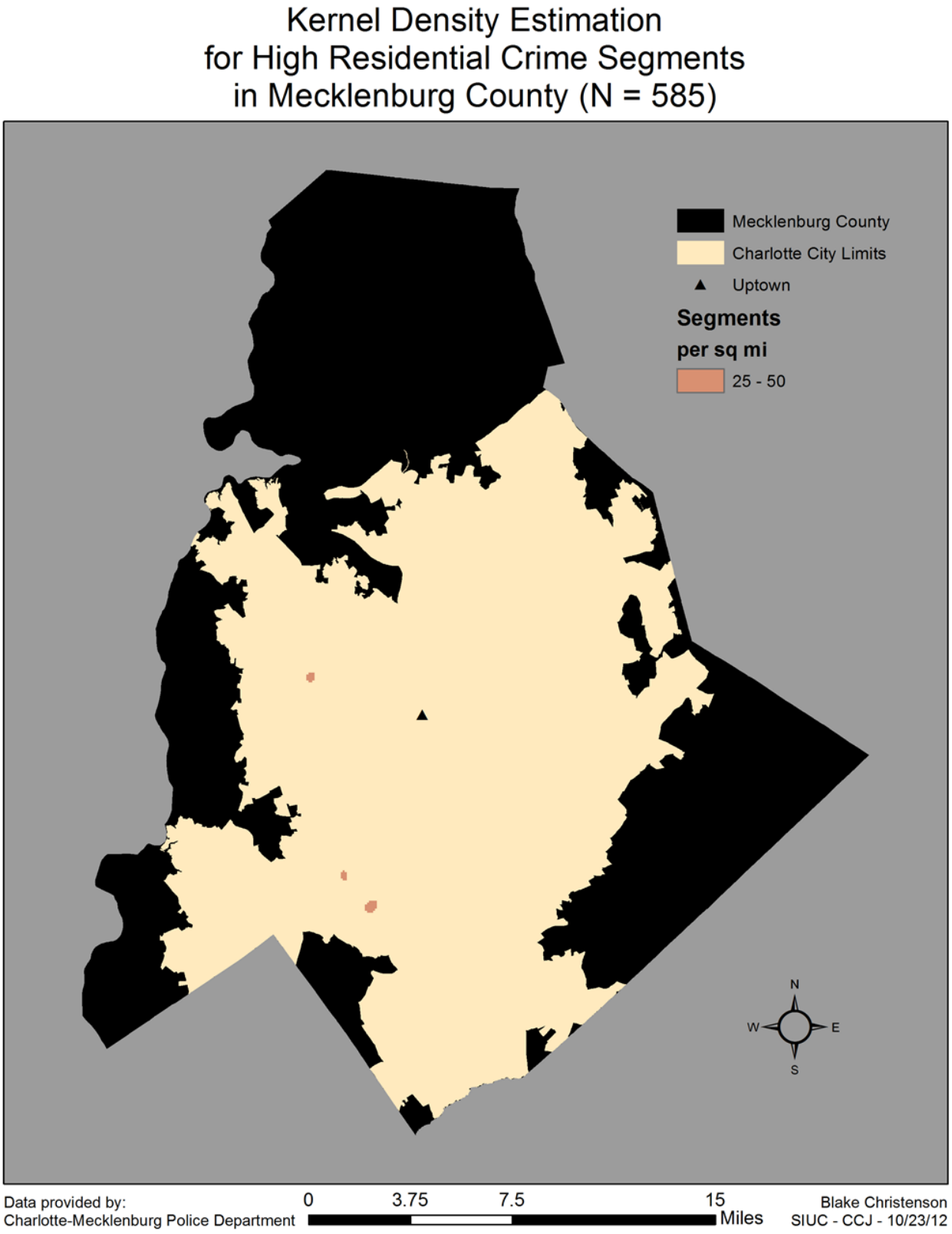

Figure 5. Kernel density estimation for high residential crime segments

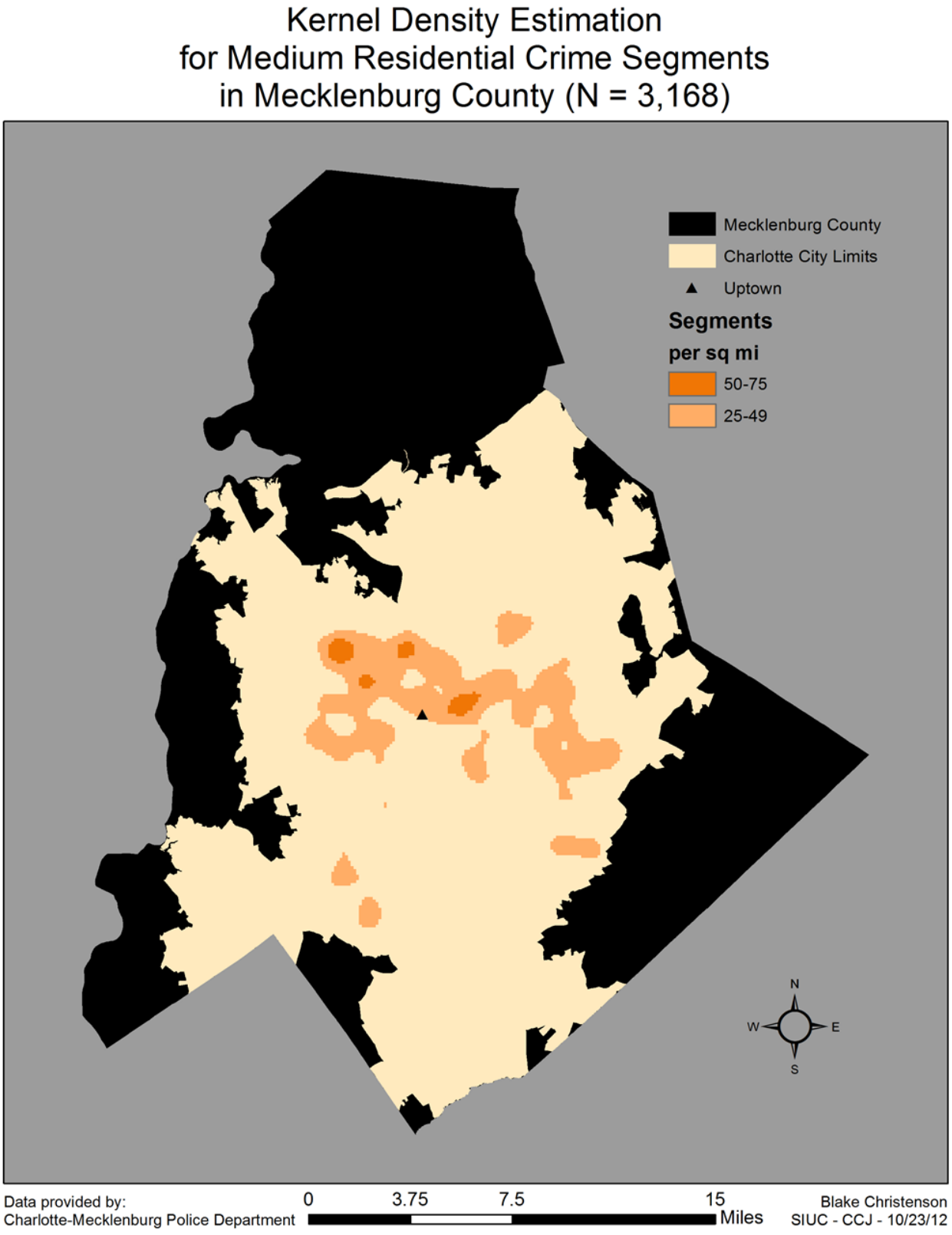

Figure 6. Kernel density estimation for medium residential crime segments

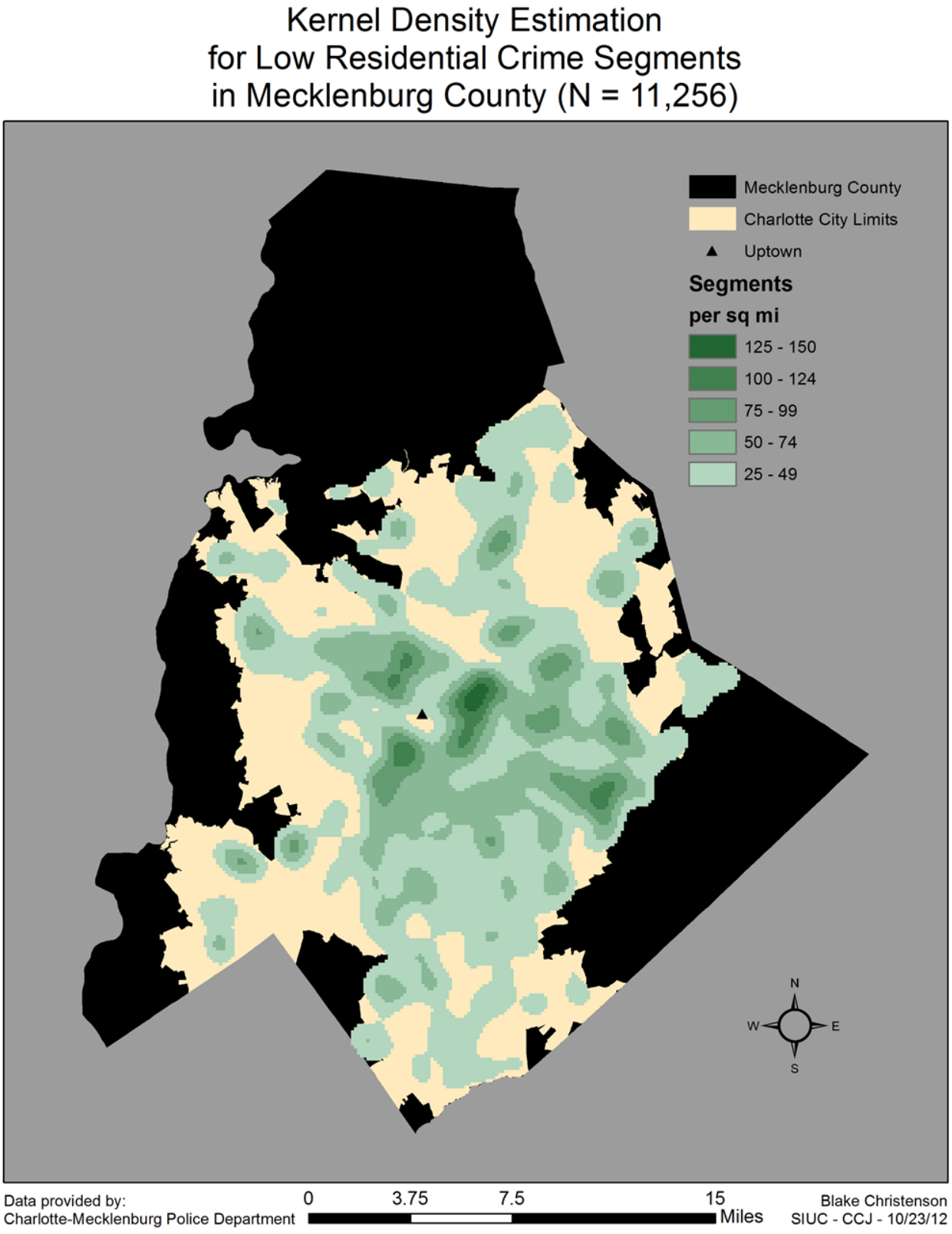

Figure 7. Kernel density estimation for low residential crime segments

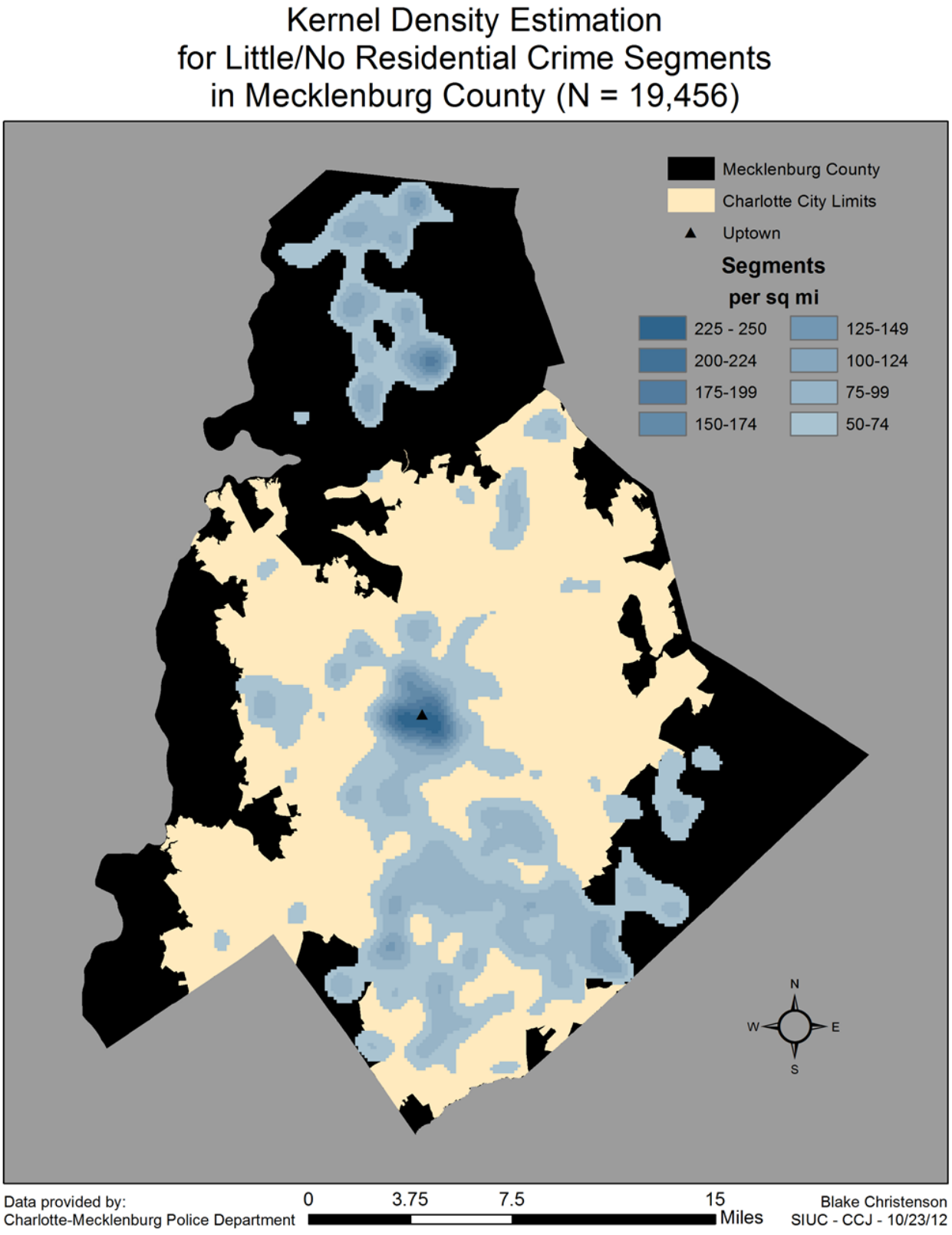

Figure 8. Kernel density estimation for little/no residential crime segments

Descriptive Statistics: Foreclosures

As mentioned, foreclosure here measures the occurrence of a foreclosure filing by address over a six year time period. The data do not allow for a yearly foreclosure breakdown. For example, a foreclosed property in 2009 might have also been foreclosed in previous years, potentially masking the true counts of foreclosure between 2004 and 2008. Instead, foreclosures across the entire study period are aggregated by street segments to indicate how many properties on a particular street segment have a foreclosure on file between 2004 and 2009. Segments average 0.466 foreclosures during the six year study period (standard deviation = 1.848), with a maximum of 92 foreclosures. Furthermore, according to the designated coding scheme (0 foreclosures, 1-2 foreclosures, or 3 or more foreclosures), 27,393 (79.48 percent) segments have no foreclosures; 5,629 (16.33 percent) segments have one or two foreclosures and account for 7,009 (43.68 percent) foreclosures during the study period; 1,443 (4.19 percent) segments have three or more foreclosures and accounted for 9,038 (56.32 percent) foreclosures during the study period (see Table 5).

Table 5

Foreclosures at street segment descriptive statistics

Foreclosed Properties per Segment	Total Foreclosed Properties	Percent of Total Foreclosed Properties	Number of Segments	Percent of Total Segments
0	0	0.00%	27,393	79.48%
1-2	7,009	43.68%	5,629	16.33%
3+	9,038	56.32%	1,443	4.19%
Total	16,047	100.00%	34,465	100.00%

Figure 9 shows the KDE for foreclosures in Mecklenburg County. These data show the greatest foreclosure density along the northern edge of Charlotte city limits

peaking between 400 and 425 foreclosures per square mile. Secondary foreclosure concentrations also peak east of Uptown with densities between 275 and 299 foreclosures per square mile. Notably, the area extending south from Uptown was (relatively) devoid of foreclosures. This non-random pattern indicates foreclosures are clustering in distinct neighborhoods in Mecklenburg County.

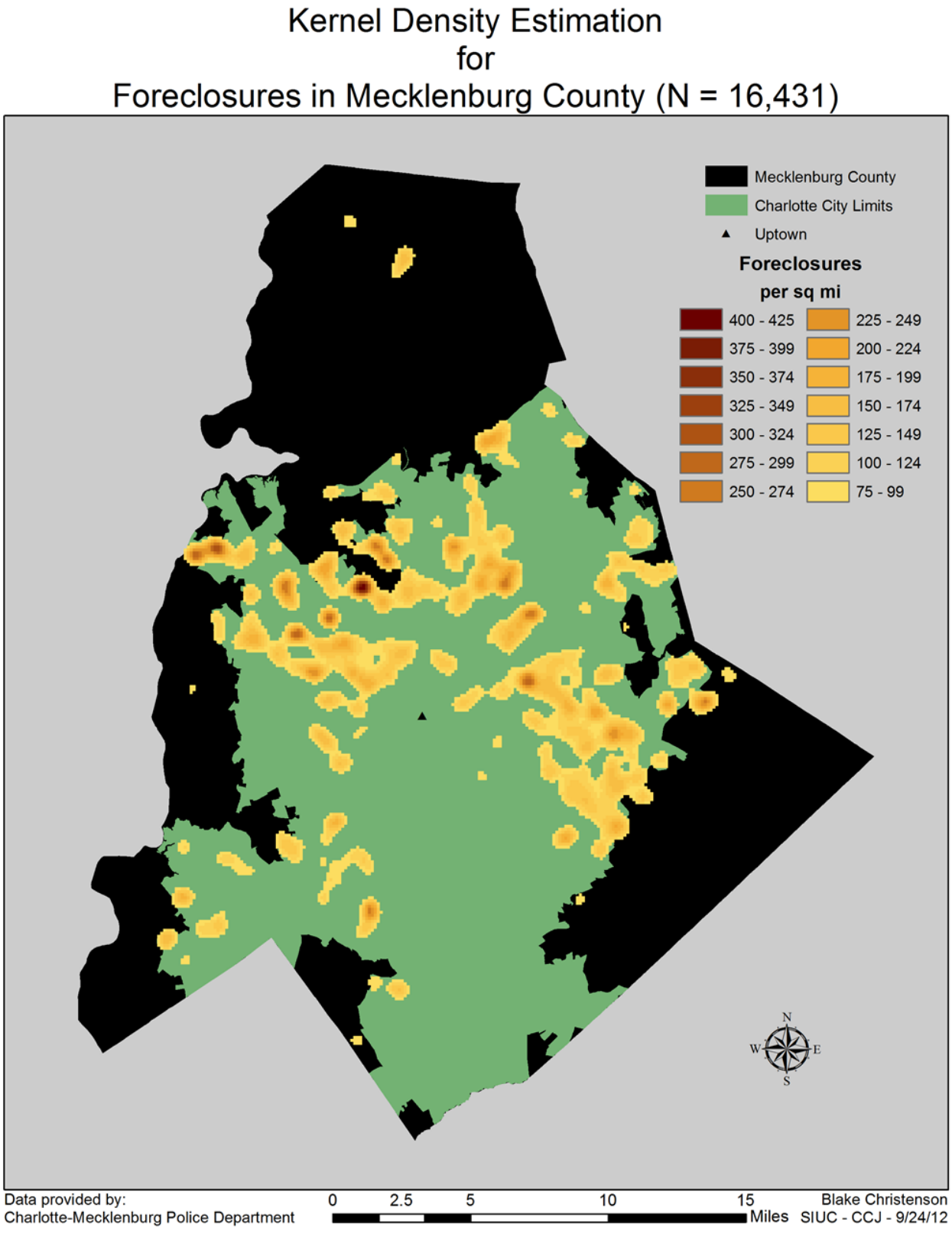

Figure 9. Kernel density estimation for foreclosures

Analysis Plan

Two statistical tests are used in order to test the bivariate relationship between foreclosure and crime. First, as the foreclosure problem increases, crime trajectory should increase. To test this relationship, the foreclosure category (0 foreclosures, 1-2 foreclosures, and 3+ foreclosures) and crime trajectory grouping (high crime, medium crime, low crime, and little/no crime) are compared using a chi-squared analysis. This chi-squared analysis tests for statistical difference between the observed pattern and the pattern expected under random conditions.

Second, foreclosures are expected to influence not only the street segment on which they occur, but also nearby street segments. This follows the principle first noted by Waldo Tobler (1970). Tobler's Law (Tobler, 1970) states that all things are inter-related, but nearer things are more related than more distant things. For the case of street segments, this suggests that intersecting segments (i.e., all segments that share an intersection) and neighboring segments (i.e., segments that share a common census block) are interconnected due to spatial proximity. Specifically, the characteristic found on a street segment are similar to surrounding segments plus a foreclosure on one segment may increase crime on surrounding segments. Moran's *I* and local indicators of spatial autocorrelation (LISA) tests for this spatial relationship using foreclosed properties between 2004 and 2009 and the total residential crime counts between 2005 and 2010 are used to test this spatial relationship.

CHAPTER 4

RESULTS

Chi-square Test

The foreclosure-crime relationship is tested using cross tabulations in SPSS version 19. The chi squared analysis shows how an observed distribution across two ordinal data sets differs from the results expected under complete randomness. The results are presented in Table 6. Street segments with 3 or more foreclosures have greatest deviation above expected values in the high crime trajectory (170, 6.8 times more than expected) and medium crime trajectory (737, 5.6 times more than expected). Furthermore, segments with 3 or more foreclosures show the greatest deviation below expected values in the little/no crime trajectory (105, 7.76 times less than expected). Segments with one or two foreclosures over the study period also show deviations from expected values; these segments are more likely to fall in the medium and low crime trajectories and less likely to fall in the high crime and little/no crime trajectories. Therefore, these segments experience more crime than the segments with no foreclosures but less crime than segments that had three or more foreclosures. Finally, segments with no foreclosures are less likely to fall in the high, medium, and low crime trajectories. All of these deviations are in the hypothesized direction (i.e., increasing the number of foreclosed properties should increase crime) and the chi-square and gamma values are statistically significant beyond the 99.9 percent confidence level.

Table 6

Chi square results for segment trajectory grouping and foreclosure category

Trajectory Group	Foreclosures			Total
	0	1-2	3+	
High Crime	365 (465)	50 (96)	170 (25)	585
	1.3%	0.9%	11.8%	1.7%
Medium Crime	1570 (2518)	861 (517)	737 (132)	3168
	5.7%	15.3%	51.1%	9.2%
Low Crime	7690 (8946)	3135 (1839)	431 (471)	11256
	28.1%	55.7%	29.9%	32.7%
Little/No Crime	17768 (15464)	1583 (3178)	105 (815)	19456
	64.9%	28.1%	7.3%	56.5%
Total	27,393	5629	1443	34465
	79.5%	16.4%	4.2%	

$\chi 2 = 7{,}102$, $p < .001$, $\gamma = .648$, $p < .001$, expected values in parentheses, percentages by column

Moran's I and LISA

Next, Moran's *I* and LISA statistics test the foreclosure-crime relationship using OpenGeoDa version 1.2.0. Moran's *I* values have a maximum value of 1.0 (perfect positive spatial autocorrelation), a minimum value of -1.0 (perfect negative spatial autocorrelation) and values near 0 show no spatial relationship. LISA maps further show a spatial relationship at the local level (i.e., areas where the overall pattern is strongest or areas where the overall pattern does not hold). Here, LISA maps show areas of positive, negative and insignificant spatial relationships relating to foreclosure and crime. In order to run these tests of spatial dependence, first a spatial weights matrix must be established. Here, as previously mentioned, intersecting segments and segments that share a census block should be most spatially related per Tobler's Law

and make up the weights matrix for each segment.

However, before assessing the foreclosure-crime relationship, I first tested for spatial auto-correlation for crime and for foreclosure. Housing foreclosures show a significant level of autocorrelation. The Moran's *I* for foreclosures is 0.1819; for every standard deviation increase in the foreclosure count, nearby segments also have more foreclosures by a factor of 0.1819 standard deviations (see Figure 10). This values shows foreclosures are weakly autocorrelated across urban space; this relationship is statistically significant beyond the 0.001 level. The LISA map (Figure 11) shows areas of positive and negative spatial autocorrelation for foreclosure. In these maps, areas of positive spatial autocorrelation are show in dark colors (red and blue) and areas of negative spatial autocorrelation are shown in light colors (pink and light blue). The LISA map for foreclosed properties show three clusters of high foreclosure segments near other high foreclosure segments: 1) along the northern edge of Charlotte city limits, 2) in the central eastern portion of Mecklenburg county, and 3) in the southwestern corner of the county. Notably, segments in a wedge south and east of Uptown show negative spatial autocorrelation (i.e., segments of high foreclosure near segments of low foreclosure).

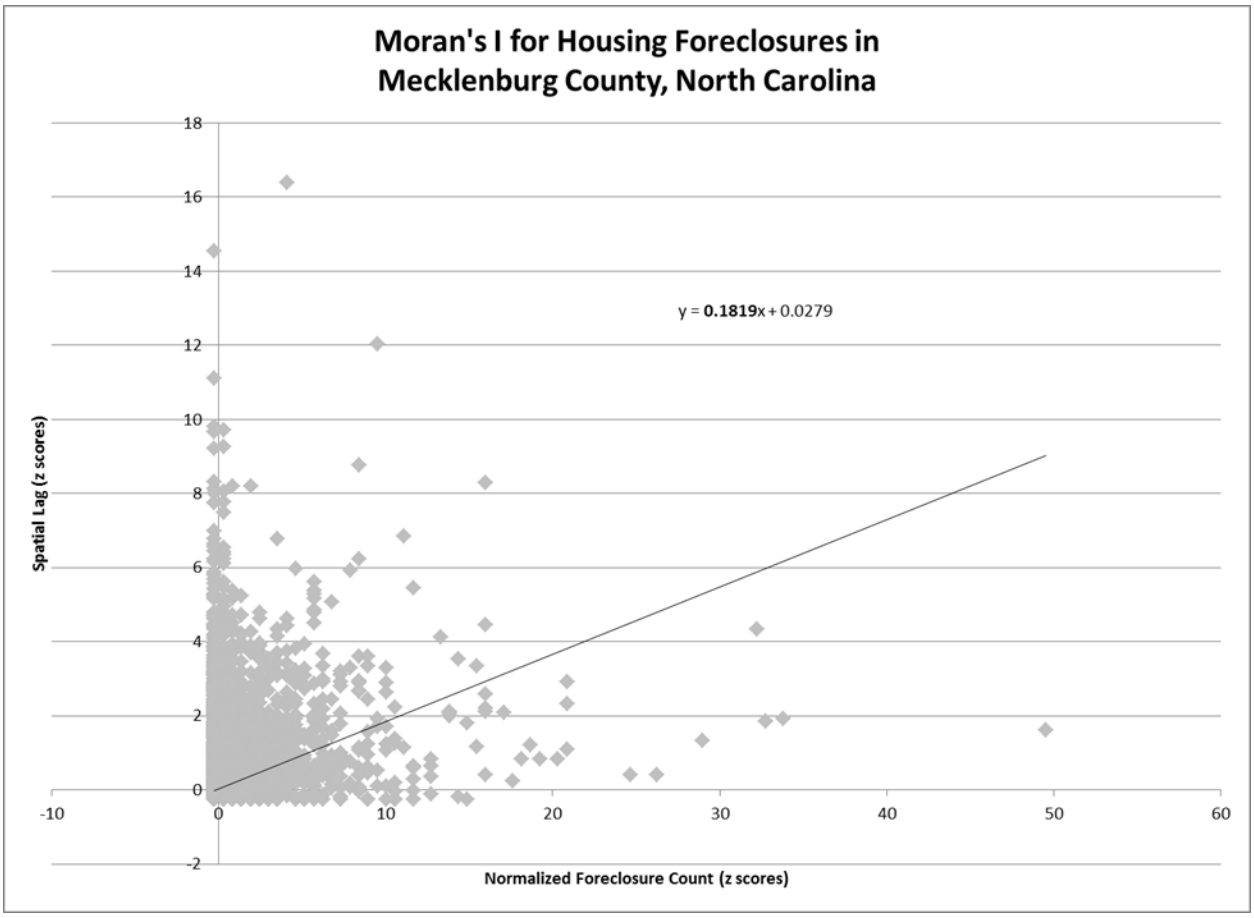

Figure 10. Moran's *I* (0.1819, $p < .001$) scatterplot for housing foreclosures

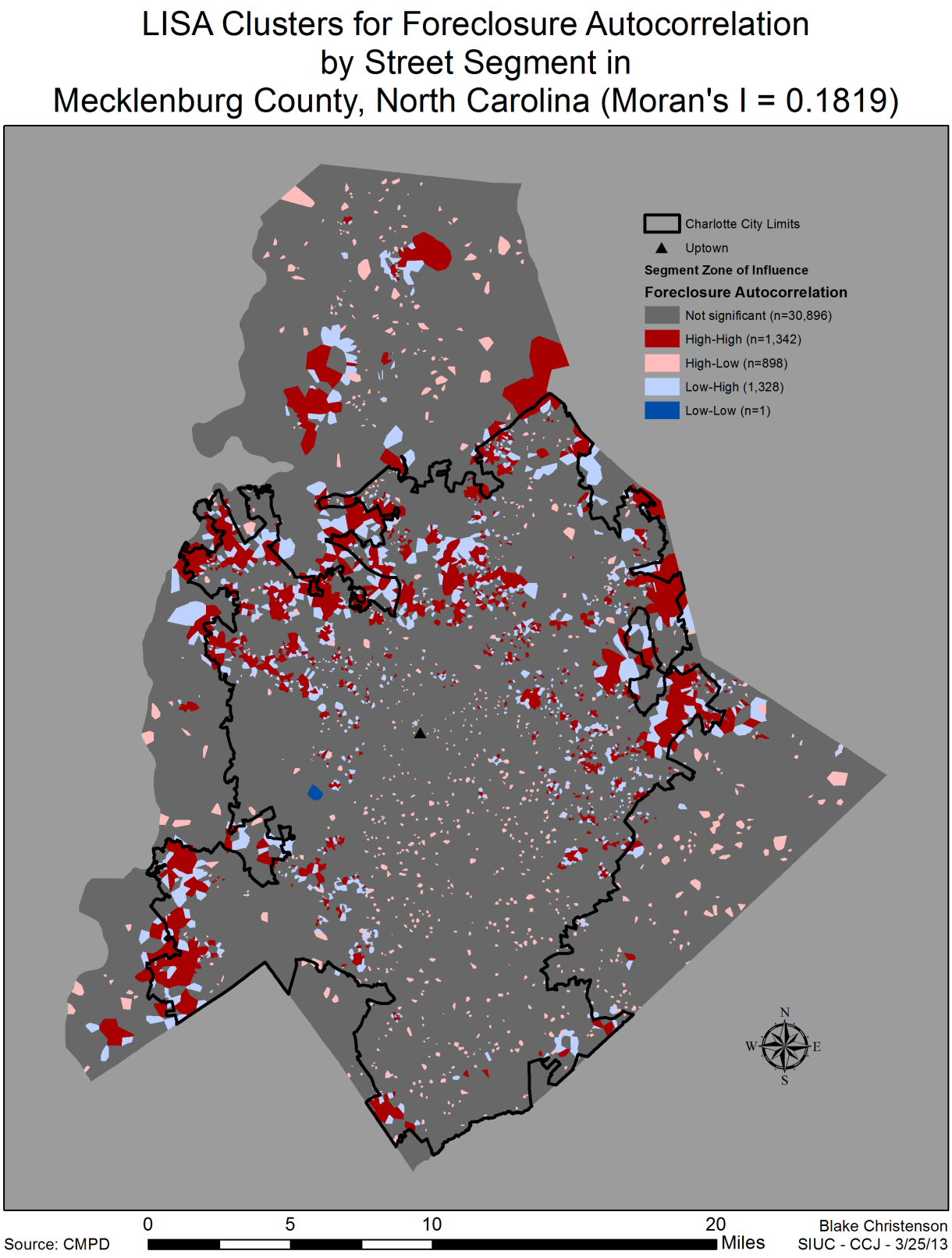

Figure 11. LISA clusters for foreclosures (Moran's I = 0.1819, p < .001)

Crime counts also show a significant level of autocorrelation across street segments. The Moran's *I* for crime counts is 0.2961 and is statistically significant beyond the 0.001 level (Figure 12). The LISA map of crime counts (Figure 13) shows some similar patterns to the foreclosure LISA map; specifically, high crime segments cluster near other high crime segments in along the north edge of Charlotte city limits with the wedge south and east of Uptown showing non-significant levels of spatial autocorrelation. The northern region (Cornelius, Davidson, and Huntersville) and the southeastern region (Matthews and Mint Hill) of Mecklenburg County show significant clusters of low crime segments near other low crime segments.

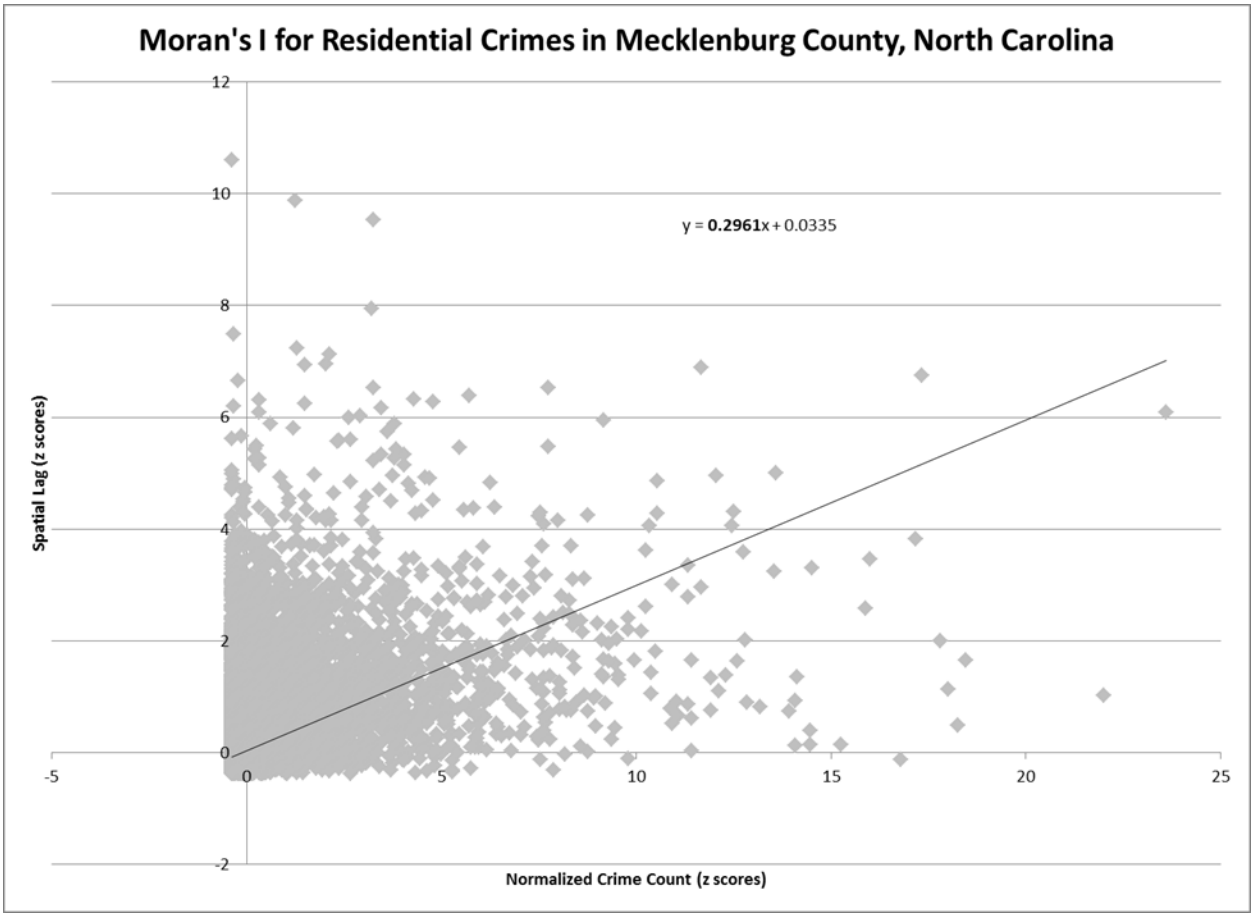

Figure 12. Moran's *I* (0.2961, p < .001) scatterplot for residential crimes

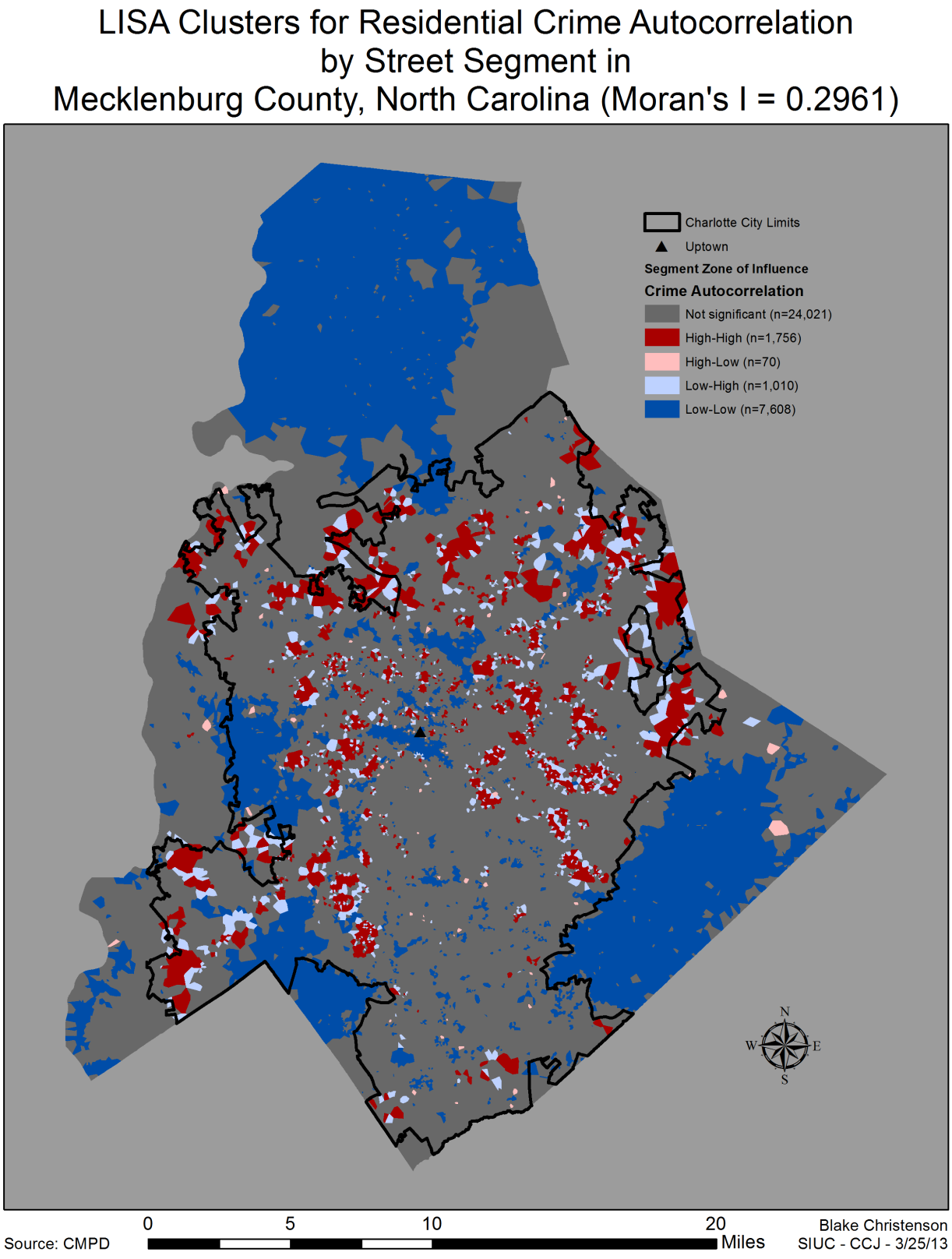

Figure 13. LISA clusters for residential crimes (Moran's I = 0.2961, p < .001)

I then applied a bivariate Moran's *I* and LISA test to examine the spatial dependency between foreclosure and crime. The Moran's *I* value for the foreclosure-crime relationship is 0.1125 and was statistically significant beyond the 0.001 level (Figure 14). The bivariate LISA map shows clear areas of positive spatial correlation between foreclosures and crime, both high foreclosure segments near high crime segments and low foreclosure segments near low crime segments. The high foreclosure-high crime segments cluster along the northern edge of Charlotte city limits (Figure 15). The low foreclosure-low crime segments cluster in the northern (Cornelius, Davidson, and Huntersville) and southeastern (Matthews and Mint Hill) regions of Mecklenburg County.

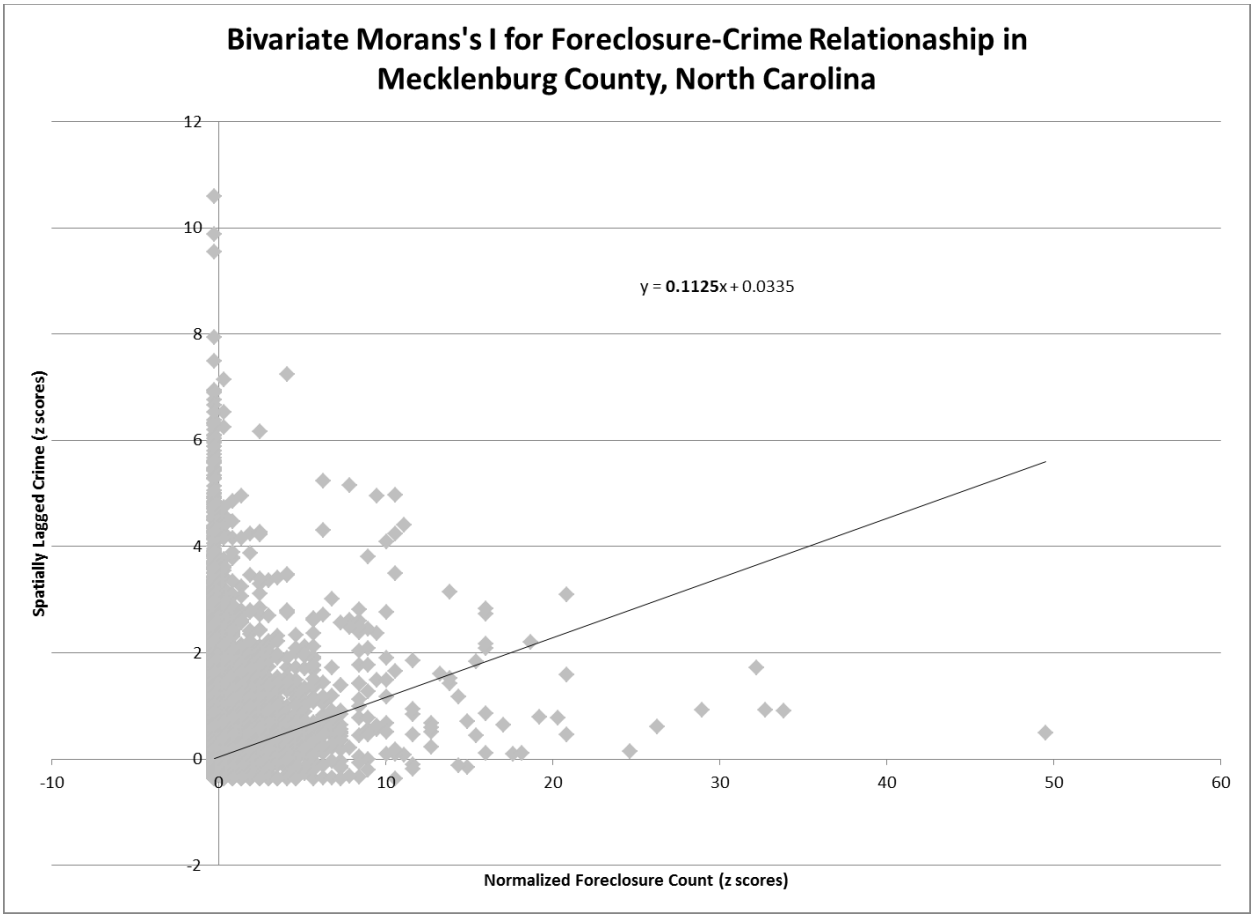

Figure 14. Moran's *I* (0.1125, p < .001) scatterplot, residential crime versus foreclosure

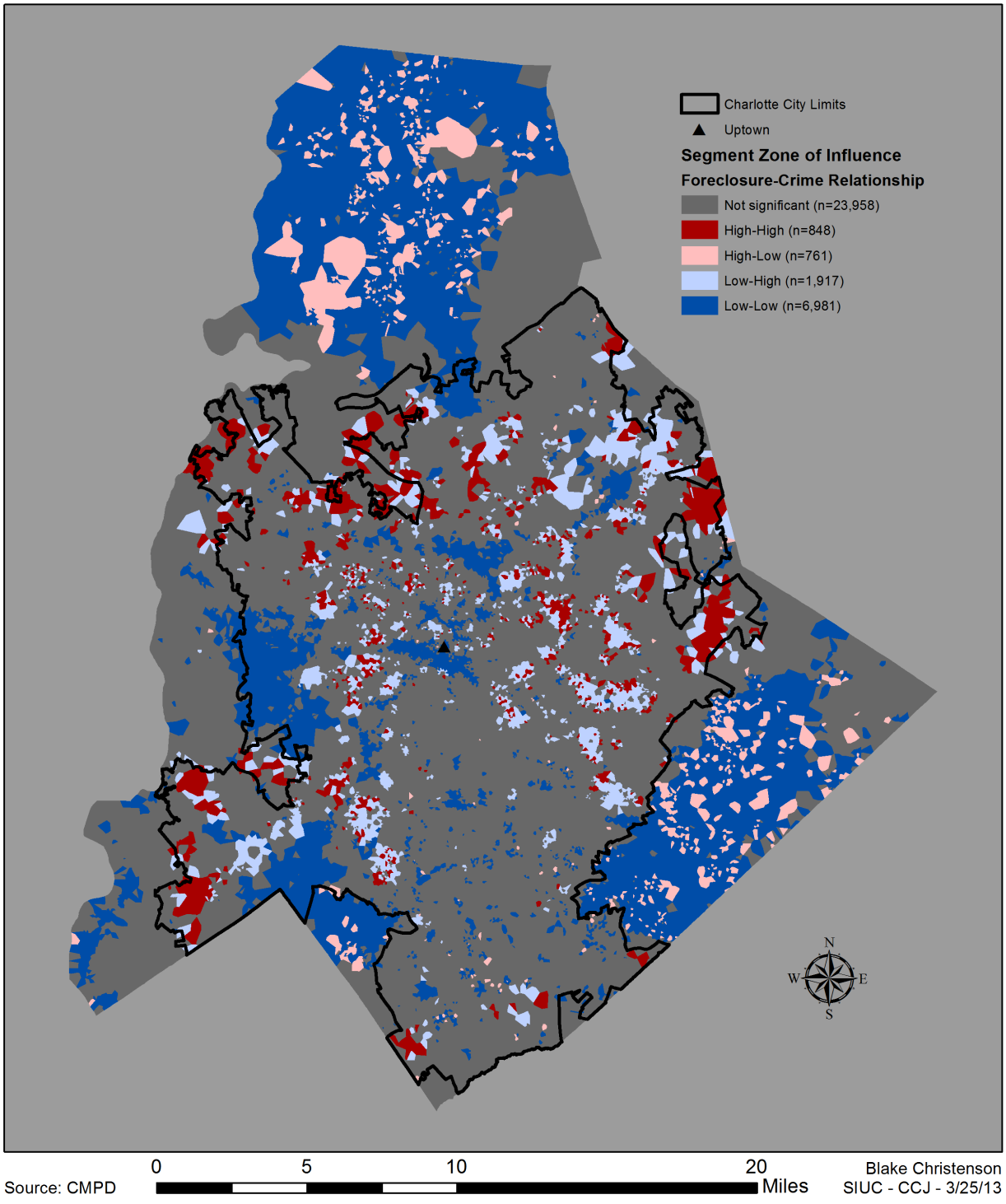

Figure 15. LISA clusters, foreclosure-crime relationship (Moran's I = 0.1125, p < .001)

Post hoc exploratory analysis shows factors that influence regional differences in the foreclosure-crime relationship. First, the foreclosure-crime relationship is distinct between segments within and outside Charlotte city limits. In particular, foreclosures are not impactful on crime outside of Charlotte city limits. Secondly, areas with higher owner occupancy rates have more opportunities for foreclosure. In these high owner occupancy areas, foreclosures and crime are positively correlated in space (e.g., northwest Charlotte, east Charlotte) (see Figure 16). However, in areas predominated by renter occupied housing, foreclosure cannot identify newly vacated homes. Therefore, the relationship in renter occupied areas is mixed between positive, negative, and no correlation (e.g., areas southwest running to northeast of Uptown). Thirdly, wealth appears to impact the foreclosure-crime relationship. Wealthy areas within Charlotte (e.g., the southern wedge) (see Figure 17) show no relationship between foreclosure and crime. Demand for housing in these areas may buffer the criminogenic impact of foreclosure (i.e., foreclosed properties do no remain vacant long).

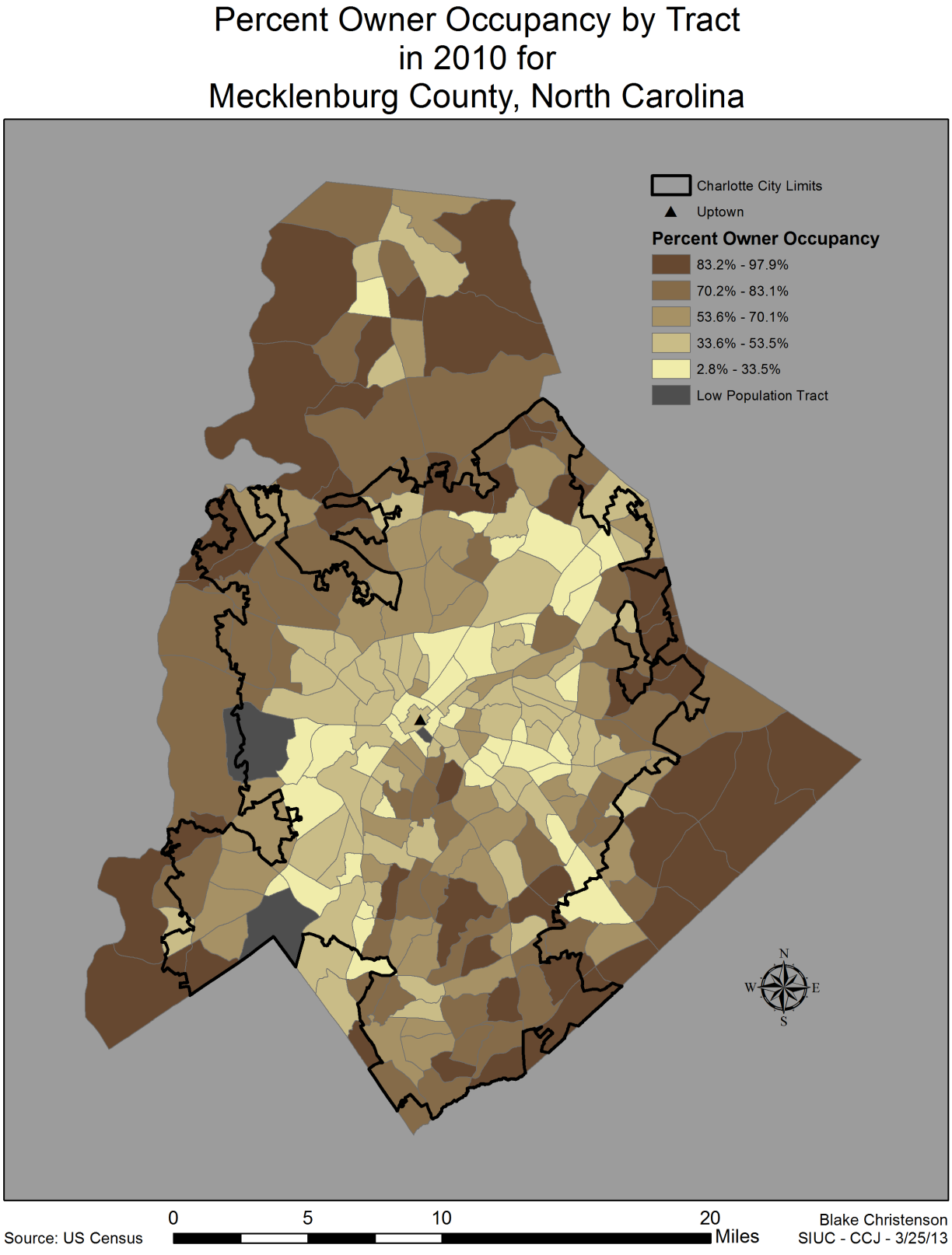

Figure 16. Percent owner occupancy by tract in Mecklenburg County

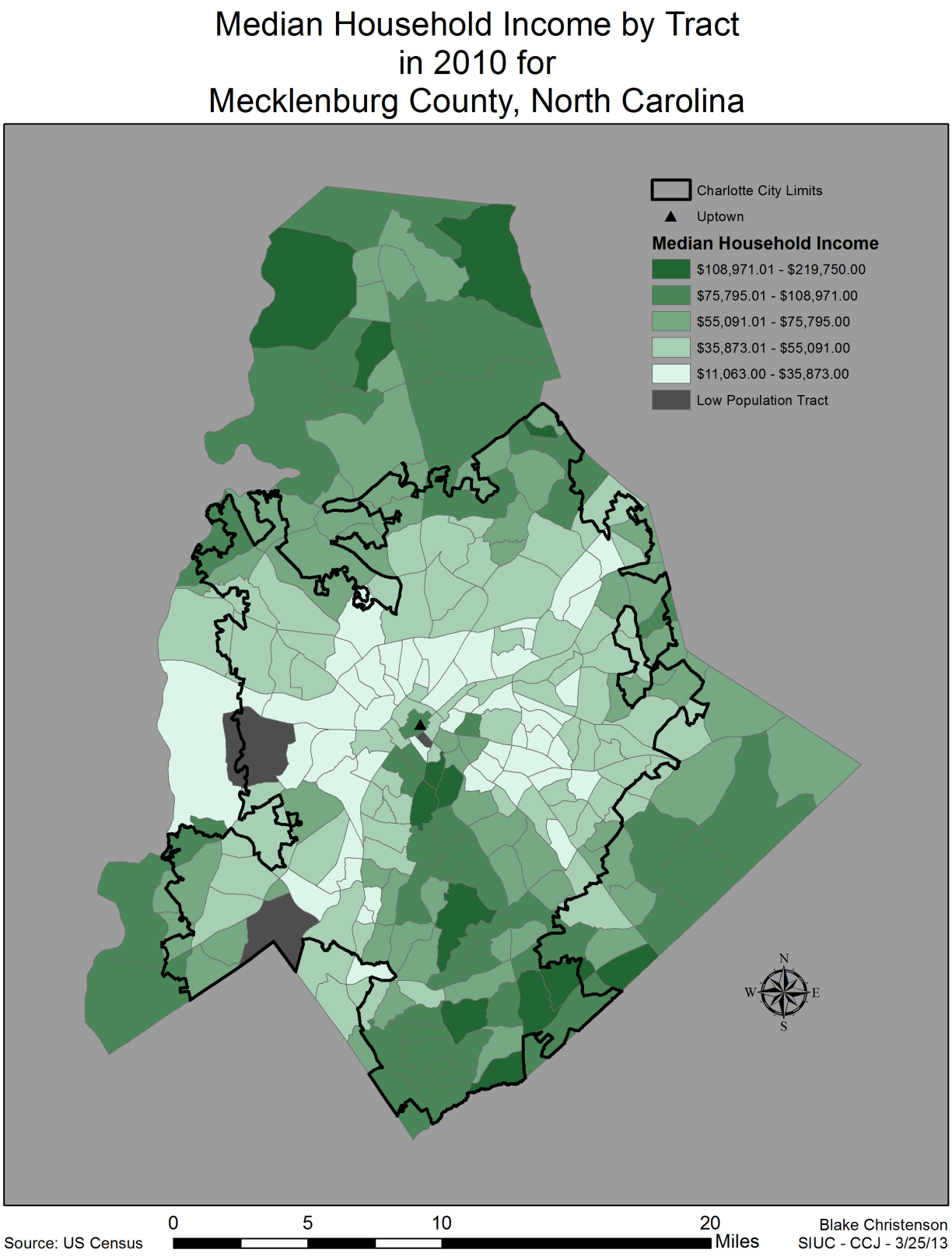

Figure 17. Median household income by tract in Mecklenburg County

CHAPTER 5

DISCUSSION AND CONCLUSION

Discussion

This research presented the bivariate relationship between foreclosure and crime measured at small areal units. Particularly, this research fills an existing gap in the foreclosure-crime literature: assessing the impact of foreclosures at micro-places (e.g., addresses, street segments). Four main findings should be extrapolated from this research. First, this research finds a significant positive relationship between foreclosure and crime at each subsequent step up in foreclosure category. Specifically, segments with no foreclosures during the study period are most likely to be in the little/no crime trajectory group; segments with moderate (1-2) foreclosure segments are more likely to be in the low and medium crime trajectory groups; and problematic (3+) foreclosure segments are more likely to be in the medium and high crime trajectory groups. Therefore, with each subsequent increase in foreclosure category, the crime level also increases.

Secondly, LISA maps show foreclosures cluster across urban space, supporting the findings of Immergluck and Smith (2006b). This suggests a potential contagion effect of foreclosure on surrounding properties. Contiguous areas of high foreclosure segments are located along the northern, eastern, and southwestern edges of Charlotte city limits. Notably, these are middle income neighborhoods (see figure 16). An opposing pattern emerges in high income areas where foreclosures show negative spatial autocorrelation (e.g., the high income wedge south of Uptown). Foreclosures high income areas do not exert the same level of contagious effect, further supporting

the findings of Immergluck and Smith (2006b) that foreclosure in wealthy neighborhoods is more sporadic.

Additionally, contiguous areas of high foreclosure-high crime clusters are most prevalent in middle income areas (e.g. along the northern, eastern, and southwestern edge of Charlotte city limits) and appear to drive the positive foreclosure-crime relationship. On the other hand, high income tracts show almost no impact of foreclosure on crime. Primarily, this is because foreclosures are rare in these high income areas; however, when foreclosures occur in high income neighborhoods, properties do not remain vacant as long as they would in low income neighborhoods (Whitaker, 2011). Furthermore, high income areas have greater levels of non-resident guardianship (e.g., burglar alarms), controlled access, and stay-at-home parents, further insulating these areas from crime. Therefore, no criminogenic impact of foreclosures is found in high income areas.

Low income tracts show both positive and negative relationships between foreclosure and crime. Foreclosures in these areas may not impactfully change the environment (e.g., existence of already vacated structure, greater density of mixed land use segments). Also, foreclosure may be infrequent in these areas due to low owner occupancy rates (see figure 17) reducing the opportunity for foreclosure (i.e., foreclosure would not measure vacancy in these areas). Importantly, spatial analysis of the foreclosure-crime relationship suggests that not all foreclosures are criminogenic; instead, more attention should be given to foreclosures in middle income areas for a crime control benefit.

Thirdly, the foreclosure-crime relationship varies regionally. This is best shown

by the foreclosure-crime bivariate LISA map (Figure 15) in which high levels of foreclosure are surrounded by low levels of crime (i.e., negative spatial correlation in these areas) in wealthy communities outside of Charlotte city limits (Cornelius, Davidson, Huntersville, Matthews, and Mint Hill) (see Figure 18). In these areas, foreclosure does not result in crime increases. In the northern county communities (Cornelius, Davidson, and Huntersville), many houses serve as second homes for wealthy Charlotte residents who use Lake Norman recreationally. Foreclosures of second homes would not impact neighborhood dynamics since these houses are not normally occupied. In comparison, high foreclosure segments within Charlotte city limits, also middle income areas, show a positive correlation with crime most notably along the northernmost edge of Charlotte city limits. These regional differences (e.g., central city versus peripheral communities) may be masking the full foreclosure-crime relationship.

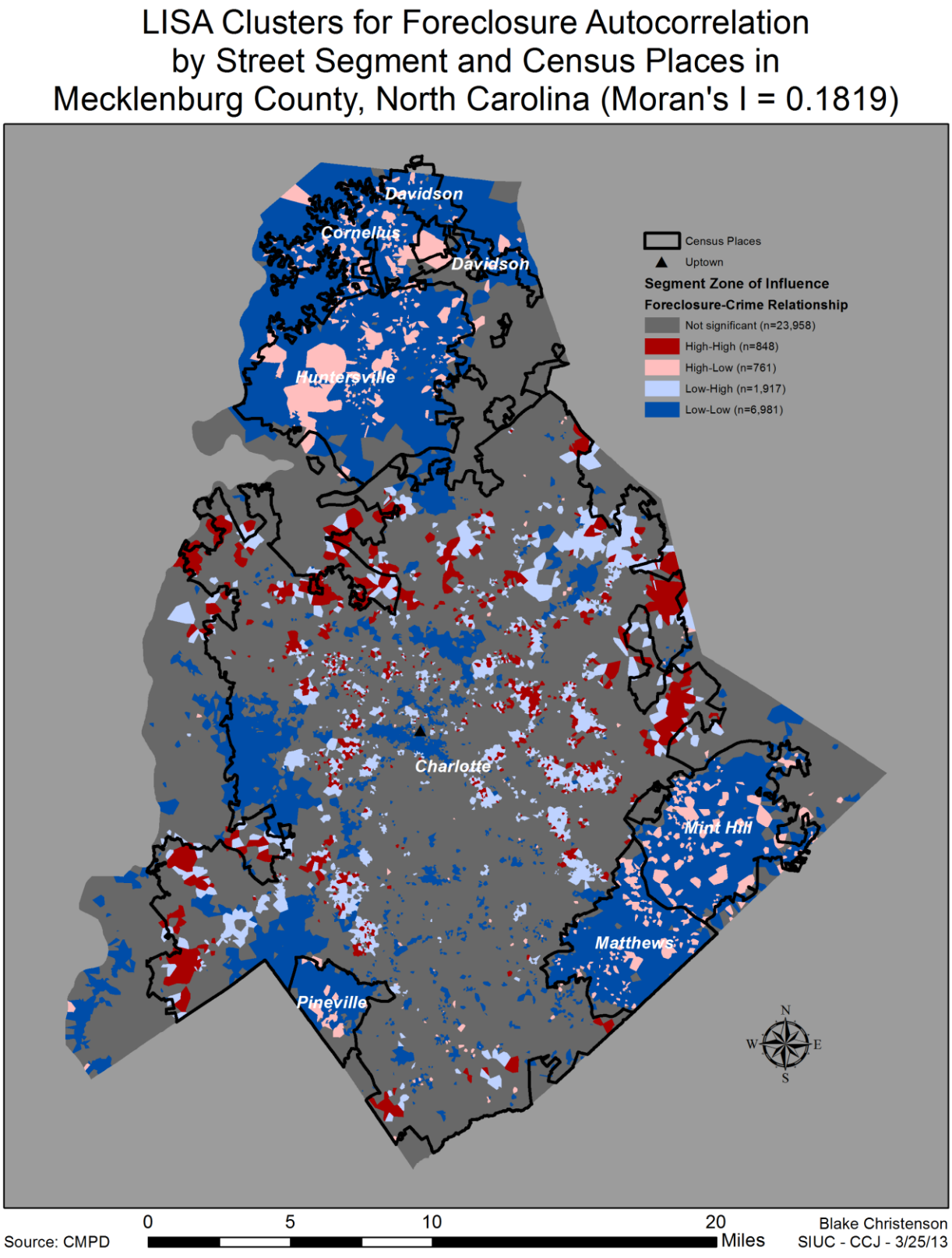

Figure 18. Census places and foreclosure-crime relationship

These patterns show two limitations of this study that may be weakening the results: 1) lack of controls and 2) failure to account for unreported crimes. Future studies should control for socio-economics, demographics, and covariates of crime (e.g., opportunity) to assess foreclosure and crime. Also, studies of the foreclosure-crime relationship should also account for the dark figure of crime. Due to the locational characteristics of foreclosed residential properties (e.g., lack of guardianship, protection from the elements, devoid of ownership), vagrants seek these structures because their illegal activities will not likely be observed and reported (see: Spelman, 1993). Moreover, property crimes (by far the most prevalent crime at residential locations) are far more likely to go unreported. National estimates show that about 60 household property crimes go unreported (Langton et al, 2012). Thus, results for the foreclosure-crime relationship based solely relying upon officially recorded crime data may be masked by the dark figure of crime.

Furthermore, future studies should establish the causal ordering of the foreclosure-crime relationship (if any). This study assumes that foreclosures increase the likelihood of home vacancy, thereby resulting in reduced guardianship and increases in residential crime. The reverse is also entirely plausible (e.g., crime rates influence residents' fear, reducing attachment to the neighborhood thereby resulting in divestment in home value and ultimately defaulting on mortgages). Likewise, exogenous variables may be simultaneously impacting foreclosures and crime (e.g., concentrated disadvantage predicting both foreclosure and crime). However, these analyses were outside the scope of this study. Instead, the analyses presented depict the nuanced nature of the foreclosure-crime relationship and may inform future research

design in order more completely understand the relationship between foreclosure and crime.

Fourth, controlling for crime location is of the utmost importance when assessing the foreclosure-crime relationship[1]. In particular, this explains the mixed results found in the foreclosure-crime literature, clarifying why certain crimes impacting primarily residential areas (e.g., burglary)[2] have more stable results while crimes impacting non-residential areas (e.g., robbery)[3] have varied results. Future studies must account for foreclosures primarily impacting residential neighborhoods and measure crime accordingly.

Importantly, this research demonstrates that not all foreclosures need to be treated equally in terms of their criminogenic effect. In particular, this research identifies two characteristics key in the identification of criminogenic foreclosures. First, foreclosures in low-middle income neighborhoods are most spatially correlated with crime. In these areas, demand for owner occupied housing is weakest. Therefore, replacements are not readily available, unlike in high income neighborhoods, to refill houses vacated through foreclosure. Second, tightly coupled foreclosures are particularly criminogenic; clustered foreclosures erode lender confidence (i.e., increases the difficulty for buyers to secure mortgage loans in high foreclosure areas) and reduce

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[1] When the analyses were rerun using crime at all types of locations (including commercial addresses), the assessed foreclosure-crime relationship is halved. Contact author for these results.

[2] From 2006-2010 in Mecklenburg County, North Carolina, 72.8 percent of all burglaries occurred at residential locations.

[3] From 2006-2010 in Mecklenburg County, North Carolina, 31.6 percent of robberies occurred at residential locations.

guardianship and neighborhood ties and increase signs of disorder. Therefore, special attention should be given to foreclosure clusters.

Conclusion

This study definitively demonstrates foreclosure and crime covary across space. Though, this study does not definitely show foreclosures result in crime, the results here provide insight into future studies of the foreclosure-crime relationship. Specifically, the research presented shows four major findings. First, street segments with three or more foreclosures over a six year time period are significantly more likely to fall in higher crime trajectory groupings. Second, foreclosures show a contagion effect, clustering across urban space. Third, foreclosure and crime show significant spatial proximity. Fourth, restricting the data set to only crime at residential locations strengthens the relationship between foreclosure and crime. Therefore, future studies that assess the criminogenic effects of foreclosure must account for spatial clustered foreclosures, control for residential crime, and strive to include the dark figure of crime.

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