Chapter 31:

Case Studies in Crime Travel Demand Modeling:

I - Travel Patterns of Chicago Robbery Offenders

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In this chapter, a case study of the crime travel demand model for Chicago, IL, robbery is discussed. Originally written in 2004, it is presented to illustrate the application of the model to a compact city with substantial transit services.

Travel Patterns of Chicago Robbery Offenders

Some neighborhoods are dangerous others are safe. Crime clusters in specific areas. So too do criminals. Criminologists, police, and civilians have known this for nearly 150 years. However, relatively little research has been done on the travel patterns of offenders. Using a modification of standard transportation models, *CrimeStat IV* allows police and researchers to describe and predict travel patterns based on four sequential models.

The object of research presented here is to test the usefulness and feasibility of CrimeStat's Crime Travel Demand model utilizing police reports of all robberies occurring in Chicago in 1997 and 1998 that had at least one known offender who lived in the city. In sum, the objectives of this study of robbery in Chicago are:

1. To test the *CrimeStat IV* crime travel demand model in a mature central city;

2. To describe the travel patterns of robbery offenders based upon offenders home and location of incident;

3. To predict the travel patterns of robbers in 1998 based upon characteristics of the offender's resident neighborhood and the incident neighborhood and a gravity model of the relationship between the two;

4. To predict the travel patterns of robbers in 1998 based upon the patterns of 1997; and

5. To assess the quality of the predictions and their value to the police.

Two Models: Econometric and Opportunistic

As outlined in Chapter 25, a travel demand model is a four-step sequential model. The first stage is trip generation, whereby the number of crimes originating in a neighborhood and the number of crimes ending in a neighborhood are modeled. The second stage is trip distribution which summarizes the number of trips that go from each origin zone to each destination zone. The third stage is mode split, which models the number of trips for each zone pair (origin zone and destination zone) that travels by a particular mode of travel. The fourth, and final stage, is network assignment which models the likely routes taken by offenders in traveling between particular zone pairs.

This mapping of links assumes that travel decisions are based upon minimizing costs to get to a valued destination. When I go to work, I weigh costs and benefits. I choose the route that will get me there quickest with the fewest problems. Early theories of criminology assumed that criminal activity was no different than other behavior. It was determined rationally. By extension, travel routes and crime locations are also determined rationally.

Trips of offenders are similar to any repeated activity. Most of our activities occur near where we live or work or on the path in between. This is our knowledge space. Trips within it maximize our efficiency and minimize costs. Daily purchases occur close to home with a rapid fall off with distance. But major purchases are an exception. They may occur far away. This distance decay can be generalized to travel cost decay. The more expensive in time, money, and distance, the less likely a trip will occur. Applied to robbery, most incidents occur close to home, but a bank robber might incur greater costs to find a good target. In addition most previous research has found that predatory criminals avoid incidents too close to home for fear that they will be recognized. Combined with distance decay, this creates a buffer zone of few criminal incidents (Rossmo, 2000).

Environmental criminology assumes that most activity occurs in a knowledge space that includes nodes of residence work and play and the routes between these (Brantingham & Brantingham, 1984; 1990). However, the components of travel for criminals may not be the same as other people. For example, for someone with a full time job, getting to work as quickly as possible is important; time is money. For a jobless criminal, time may be less important.

Routine activities theory assumes that both targets and offenders choose their activities based on a weighing of costs and benefits. Offenders seek out targets in locations where they are likely to congregate (e.g. bars at closing time, rapid transit stations). A crime occurs when an offender and a target converge in the absence of a capable guardian (Felson, 2002). The routine activities of offenders may mostly be hanging out rather than rationally seeking targets. What is the basis of convergence? Chance or the decisions of offenders? Any potential robber's decision is effected by both chance and cost. Time and distance are both measures of cost. However, within a short distance of home time and distance costs are near to zero.

An alternative hypothesis is that robbers do not weigh costs and benefits of travel. Rather, they may see an opportunity for crime and take it. Because much of their day to day activity is near home, many incidents occur near the robber's home. Travel patterns are irrelevant for these crimes. The number of robberies decline with distance from the offender's home because fewer of the robber's daily activities occur far from home. On the other hand, more professional robbers may seek out specific areas or locations where lucrative targets are found and may be willing to travel great distances.

In Chicago, an opportunistic robber's knowledge of good targets may be limited to the isolated area around his residence. In addition, trips within the area cost almost nothing, although other costs, such as risk of capture may be relatively high. The difference between Chicago and Baltimore County (or between Chicago and its suburbs) has to do as much with knowledge of the distribution of opportunities as with the cost of travel. Chicago's neighborhoods are so isolated that some offenders may have little knowledge of opportunities outside their resident area. The crime travel demand model holds that in the aggregate offenders appear to weigh costs and benefits. However, the data analyzed here says nothing about individual decisions. Decisions may be made with other factors not captured by shortest distance or time.

In one of the few studies of non-arrested robbers Wright and Decker (1997) found that most St. Louis robbers are opportunistic and rob close to home. Rationality and careful cost calculation have little to do with their decisions. These are people who have a need for quick money. If they saw an opportunity near home, they would take it. Opportunities were most likely to occur as the potential offender and victim went about their daily routine activities. Most of these happened close to home. Therefore, robbery occurred close to home.

The closer to an offender's home that an incident occurs, the more likely the incident has resulted from a chance meeting. The further away that it occurs the more likely that it was planned. Part of the planning is transportation costs. It is difficult to calculate this for offenders. The best we can do is estimate travel time.

Crime Travel Demand Modeling in Chicago

The Offender Travel Model is a new application of the Travel Demand Model. The travel demand model has been in development since the 1950's. It is used in every metropolitan area in the United States. *CrimeStat*'s crime travel demand model was outlined in Chapter 25.

As applied to robbery in Chicago, description is as important as prediction. While the Chicago Police Department (CPD) has long collected information on the location of the incident and residence of the offender, these were not linked in any systematic way. In meetings with the department, credible descriptive maps proved to be the most convincing reason to use the new *CrimeStat* travel demand module. Before a new technique is tested, its potential credibility must be demonstrated. Therefore, the last phase, in the Chicago Travel Demand Model emphasized both the predicted travel demand model and the observed travel of offenders.

Analysis of Chicago's Crime Travel Demand proceeds in three stages. The first step (trip generation) is a prediction of variables associated with the number of crimes originating in each zone and the number of crimes ending in each zone.

The second step is the prediction of links between zones based on zonal characteristics of incident locations and offender residences and a measure of the attraction between the two zones. These predictive models are compared to the observed links and trips and the previous year's trips used as a prediction.

The mode split step was not run because of the lack of data. Unfortunately, the Chicago police data does not permit an analysis by different modes of transportation (see Chapter 29). Data on whether the offender drove, walked, or rode rapid transit to the incident are not collected.

The final step is the description of probable travel routes from the offender's home zone to the incident zone based on shortest time or distance along a transportation network. The links modeled in the second step can be converted to a probable route between home and incident zones over a road network or a summary network load which aggregates travel of all offenders along a transportation network.

Data for the Chicago Study

Incident and Arrest Files

The analysis presented here merged information from many sources. This research is based on incident and arrest records from the CPD. Excluding O'Hare Airport, the city of Chicago is divided into 946 traffic analysis zones. Incidents are assigned to these zones for both residence location (the origin) and the crime location (the destination). These include all Chicago robberies in 1997 and 1998 that had at least one known offender who lived in Chicago. These were geocoded by the address of the incident and the home address of all known offenders. Offenders who traveled longer distances were probably under-represented (Block, 2007). About 20% of all reported robberies were included. In 1997, there were 25,000 robberies reported to the police. Of these robberies, 4,636 resulted in the arrest of at least one Chicago resident. Including robberies with multiple offenders, there were 6,643 crime trips.

Traffic Analysis Zones

These incidents and offenders are counted in 946 Traffic Analysis Zones (TAZ). O'Hare Airport is excluded. Chicago's traffic analysis zones are mostly based on a uniform grid of 1/2 mile squares. These are not based on census tracts or other city divisions. However, some census data was available for these zones along with information on employment. About 100 of them had no census population and therefore were unlikely to include the residence of an offender. Land use, employment, population, and robbery incident and offender residence counts were available for all zones. Land use goes beyond the standard census measures to include characteristics from many data sources that might be related to crime. Among these are code violations, vacant parcels, fires, liquor licenses, pawn shops, entertainment venues, distance from the central business district and other potentially criminogenic characteristics.[1] These traffic analysis zones were the unit of analysis. Trips were defined from the center of a zone.

Chicago's Road Network

The base of Chicago's road network is a grid with 1/8 mile between blocks, a feeder street every half mile, and a main street every mile. Layered on top of this grid is a series of diagonal streets that tend to be major shopping streets and a relatively small number of expressways that converge at the edge of the central city. A semi-expressway, Lake Shore Drive, runs along the lakefront for 25 miles. Chicago has a well developed rapid transit system that, unfortunately, could not be included in the current analysis.

Two street networks were available for analysis:

1. **Modified TIGER Line File**: A mostly complete map of all streets and rail lines. Following police practice, the modified TIGER file allows for geo-coding in non-addressed areas, such as parks, by extending the base grid. All public streets are included, but one-way streets are not taken into account and the shortest distance may be on a route that no one would travel. Some areas of the city were not well mapped.

2. **Modeling network:** This includes Expressways, principal arterials and collector roads. Each road segment is uni- (or single-) directional; that is, it expresses travel in only one direction. Thus, for a two-way road, there will be two records for every segment, one in each direction. This has the advantage that one-way streets can examined since there will not be an opposite direction pair. On the

1 In contrast to many cities, Chicago has a large population living in the central business district and lacks a ring of impoverished communities surrounding downtown.

other hand, a modeling network is less complete since minor streets are ignored. This type of map is useful for capturing trips that occur over a mile or more, but is not very useful for the many trips of less than 1/2 mile that occur in Chicago. It does take into account one-way streets. Using distance, the network will over-emphasize surface diagonal streets and will under-emphasize expressways.

One of the advantages of the modeling network is that street segments can be weighted by speed or travel time, rather than just distance. There are eight distinct time periods with the travel time on each segment by period being indicated. Each street segment can be weighted by its travel time in minutes during a specific time period (e.g.; 7- 9 AM) to allow a more realistic description of travel behavior. Further, travel in opposite directions can be treated differently since travel times can be different for each direction. During rush hour, travel in one direction may be much quicker than travel in the other direction. Weighting by travel time will allow larger arterial roads and expressways to be chosen more because travel speeds will generally be faster on the larger capacity roads. This network tends to be most realistic for longer trips but, again, is not useful for very short 'local' trips since the local, neighborhood road network is not included. A greater percentage of the travel is on expressways.

Trip Generation

Using the arrest data, events were aggregated to the TAZ's for both the origins and the destinations. As expected, the distribution of crimes by origin zone and by destination zone were highly skewed. For example, 419 zones had no robberies originate in them while one zone had 27 and another had 24 originate in them. A similar condition held for the number of crimes by destination. For example, no robberies occurred in 409 zones while one zone had 24 robberies and two had 23.

Separate models of these incident were developed at the zone level. The regression analysis tools in CrimeStat are excellent, but choosing regression predictors requires both skill and theory. Many explanatory variables were tested. The independent variables chosen for analysis were based on those previously found to be important predictors of violent crime in Chicago. Significant variables were:

1. POP2000 The most important was the 2000 population because the dependent variable was a predicted count of origins or destination. Other variables that were included were:

2. ETHNICPER The percentage of the dominant racial or ethnic group within the TAZ. Recent research (Sampson & Raudenbush, 2001) has found that racial isolation and poverty predicted high community levels of violence.

3. POVPERCENT The percent of the households below the poverty level. Sampson and Raudenbush (2001) found this to be a dominant variables explaining community disorder.

4. VENUE The number of entertainment venues (clubs, theaters, bowling allies) in a TAZ. This is information gathered from the MetroMix and the Reader in 2002. It was negatively related to the residence of the offender and was probably more a measure of perceived neighborhood safety than availability of targets.

5. PAWNSHOP The number of pawnshops is included in several regressions. A pawnshop is both a focus for potential targets and a good place to get cash.

6. VACANT: Count of vacant buildings in the TAZ. Perhaps this is an indicator of general neighborhood dilapidation (Broken Windows).

The variables that were not significantly related to origins or destinations included many that are typically related to travel demand including employment and distance from the central business district. In addition, variables that are often associated with robbery, such as counts of drug arrests, convenience stores, liquor licenses, banks and currency exchanges were unrelated to origins or destinations after poverty and population were accounted for. Few TAZ characteristics that might attract an offender to commit a crime were significantly related to the number of robbery incidents in a TAZ. In general the results of the regression models and the resulting travel demand matrix supported the depiction of robbery in Chicago as occurring in or near the offender's relatively isolated home neighborhood.

Poisson regression models for origin and destination zone counts for overnight trips were similar in 1997 and 1998. Table 31.1 presents the final Poisson regression model for the resident zone of robbers in 1998.

The Likelihood Ratio was good and an analysis of the residual errors did not reveal any major outliers. Given the large number of zones (n=946) the regression predicted variations in the count of origins fairly well.

Table 31.1:

Overnight 1998 Robbery Origin Model

Data file:	Chicago TAZ with Time.dbf
Type of model:	Origin
DepVar:	**Robbery Origins 8PM-5:59AM**
N:	946
Df:	940
Type of regression model:	Poisson with over-dispersion correction
Log Likelihood:	-2,011.35
Likelihood ratio(LR):	2,962.73 P-value of LR: 0.0001
AIC:	4,034.71
SC:	4,063.82
Dispersion multiplier:	1.00

Predictor	DF	Coefficient	Stand Error	Tolerance	z-value	p-value
CONSTANT	1	**-2.072610**	0.170828	.	-12.132746	0.001
POP2000	1	**0.000235**	0.000011	0.876420	22.156415	0.001
ETHNICPER	1	**0.015786**	0.001746	0.909463	9.042151	0.001
POVPERCENT	1	**0.037134**	0.002144	0.872974	17.321707	0.001
VACANT	1	**0.016970**	0.002528	0.835809	6.712064	0.001
VENUE	1	**-0.115182**	0.033458	0.933336	-3.442566	0.001

Similarly with the destination model (Table 31.2), the Likelihood Ratio of the destination model was reasonably good, though not as strong as with the origin model. There were not any apparent major outliers. Given the large number of zones (n=946) the regression predicted variations in the count of destinations fairly well.

In both regression models, population had a positive relationship to the number of crimes. Similarly, the poverty variable and the ethnic homogeneity variable were positively related to the number of crimes, both origins and destinations.

Table 31.2:
Overnight 1998 Robbery Destination Model

Data file:	Chicago TAZ with Time.dbf
Type of model:	Destination
DepVar:	**Robbery Destinations 8PM-5:59AM**
N:	946
Df:	941
Type of regression model:	Poisson with over-dispersion correction
Log Likelihood:	-2,041.56
Likelihood ratio(LR):	2,661.30 P-value of LR: 0.0001
AIC:	4,093.11
SC:	4,117.37
Dispersion multiplier:	1.00

Predictor	DF	Coefficient	Stand Error	Tolerance	z-value	p-value
CONSTANT	1	**-1.946591**	0.032370	.	-60.135432	0.001
POP2000	1	**0.000218**	0.000008	0.898680	26.418877	0.001
ETHNICPER	1	**0.015913**	0.000874	0.944910	18.201093	0.001
PAWNSHOP	1	**0.335678**	0.029184	0.954563	11.501940	0.001
POVPERCENT	1	**0.035707**	0.001888	0.989400	18.913079	0.001

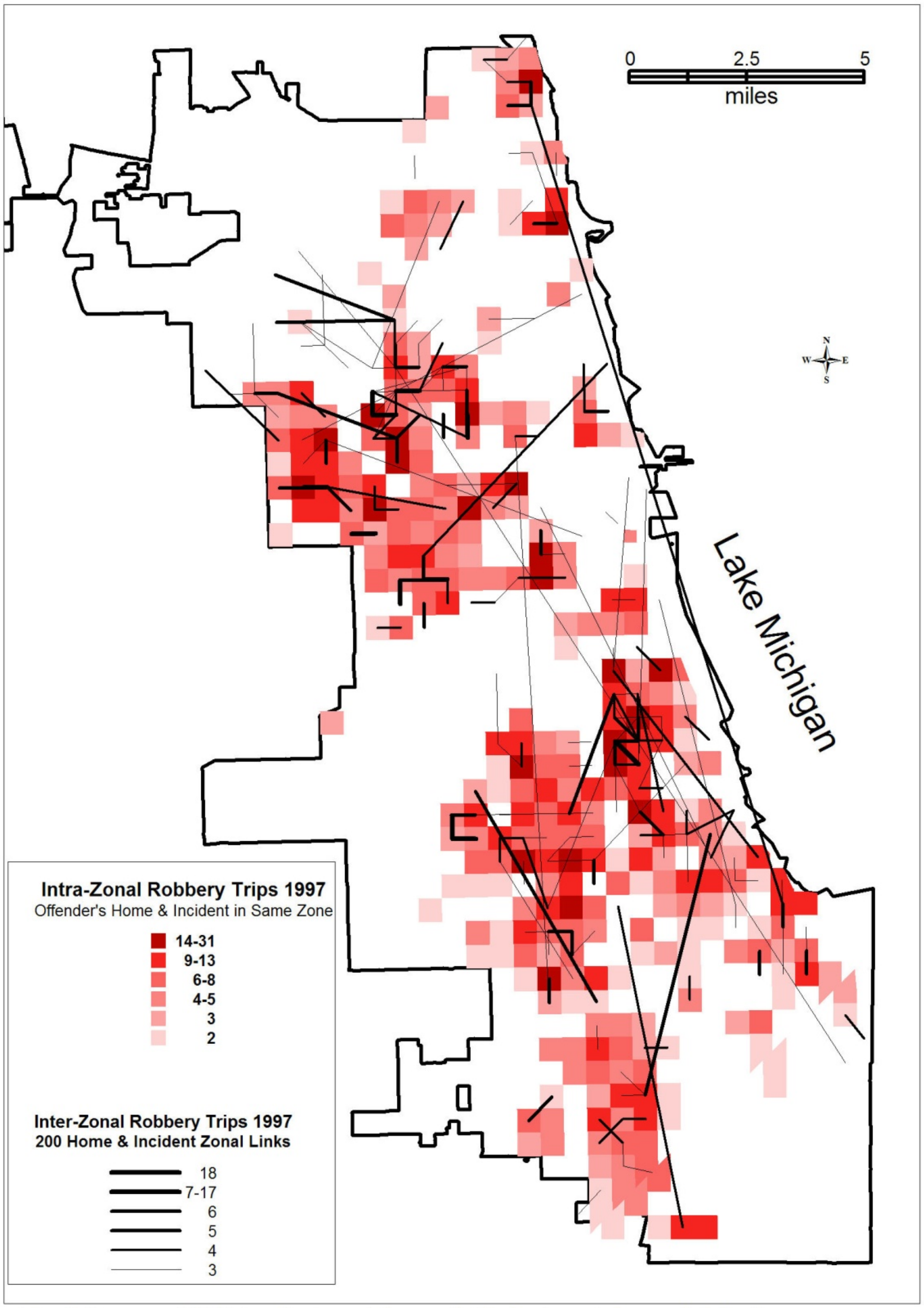
Trip Distribution

After the two predicted models were developed, the trip distribution was predicted, in other words the modeled number of trips that went from each origin zone to each possible destination zone was estimated (trip distribution). The inputs were the predicted origins and predicted destinations for robberies in 1998 from Tables 31.1 and 31.2.

The test of CrimeStat's crime travel demand module began with an analysis of 1997. Preparatory analysis indicated that 29% of robbery trips occurred in the offender's home zone. While the number of intra-zonal trips can be mapped and predicted, travel within a zone cannot be described.

Using observed crime trips, the actual number of trips from each zone to every other zone was calculated. Figure 31.1 depicts the volume of observed inter- and intra-zonal trip links in 1997. The zone shadings indicate the number of intra-zonal trips. The width of the links indicates the frequency of trip links for zones with 3 or more links.

Figure 31.1:



Robbery 1997: Intra-Zonal & Inter-Zonal Links

Source: Chicago Police Department Cartography: Richard Block, Loyola University Chicago

Impoverished areas of the west and south side dominate this analysis. Most inter-zonal links are quite short (Figure 31.2). Many begin in zones that also have many intra-zonal trips. In Las Vegas and Baltimore County many links are associated with specific sites such as shopping malls or entertainment areas. Within the City of Chicago, the links lack a clear focal zone for incidents. However, few robbery trips are made to the central business district.

From a police perspective, even the distribution of crime trips can be of value for tactical purposes and for planning interventions. However, the description of 1998 night time robberies south side dominate this analysis. Most inter-zonal links are quite short. Many begin in zones that also have many intra-zonal trips. In Las Vegas and Baltimore County many links are associated with specific sites such as shopping malls or entertainment areas. Within Chicago, the links lack a clear focal zone for incidents. However, few robbery trips are made to the central business district.

A trip distribution analysis includes both inter- and intra-zonal trips in a single analysis. The analysis is not of travel from home to destination, but from a home zone to a destination zone. For transportation planners inter-zonal trips are more important than intra-zonal trips because these predict changing transportation needs. The volume of within zone travel can be predicted but not specific routes. However, many Chicago robberies (29% in 1997, 26% in 1998) are intra-zonal.

Therefore, two techniques were tested to account for the many intra-zonal trips. First, both inter- and intra-zonal overnight robberies trips were included in the same model. Second, to see whether different variables were predicting incidents close to the offender's home address from those further away, inter- and intra-zonal trips were analyzed separately. Ultimately, I concluded that there was little to be gained by separating the two types of trips.

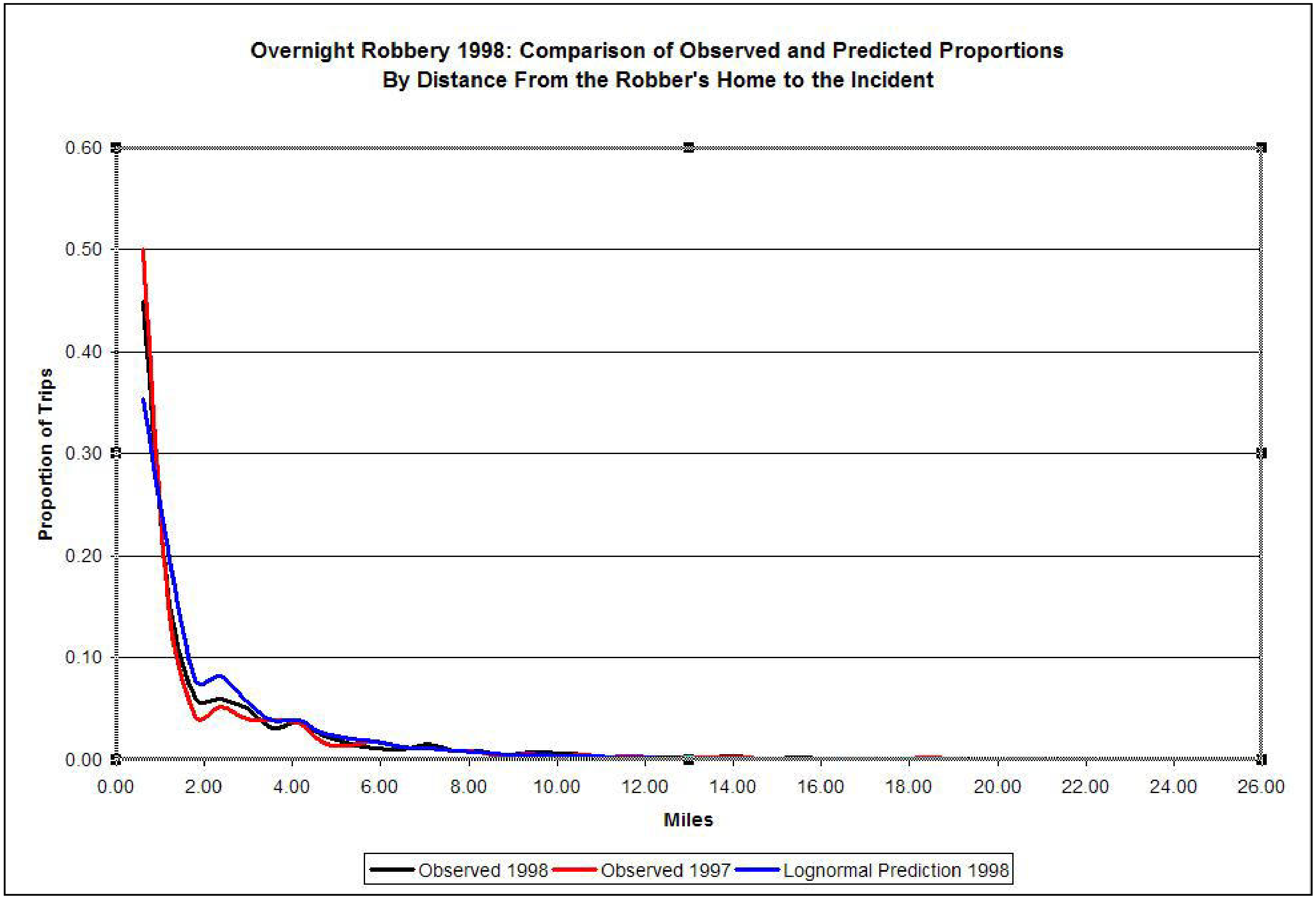
Gravity Model of Chicago Robbers

The gravity model that underlies CrimeStat's trip distribution model assumes that travel between or within zones is dependent upon the offender pool, opportunities, and costs. Conceptually, this can be written as:

$$T_{ij} = \frac{\alpha P_i \beta A_j}{C_{ij}} \qquad (31.1)$$

where T_{ij} is the number of trips from zone i to zone j, P_i is the number of offenders in zone i (the offender pool), A_j is the number of attractions or opportunities in zone j, C_{ij}^{λ} is cost of travel from zone i to zone j, α and β are coefficients and λ is an exponent. The impedance (or 'cost')

Figure 31.2:



Overnight Robbery 1998: Comparison of Observed and Predicted Proportions
By Distance From the Robber's Home to the Incident
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Proportion of Trips
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
26.00
Miles
Observed 1998
Observed 1997
Lognormal Prediction 1998

component is modeled with a mathematical function. After experimentation, I found that the best impedance function was a lognormal distribution with a mean of 2 miles and a standard deviation of 5. The resulting model fit the actual trip length distribution quite well.

Predicting 1998 Trips From 1997 Trips

Can the 1998 distribution be successfully predicted from the 1997 model? In time series analysis, the best prediction of one period is generally the period that immediately preceded it. In spatial analysis, this is also likely to be true, especially in a mature city. However, while neighborhood characteristics change slowly in Chicago, they do change. During the late 1990's many public housing projects were emptied and most were torn down. While few neighborhoods deteriorated, many gentrified. Any of these might cause a change in the distribution of robbery trips.

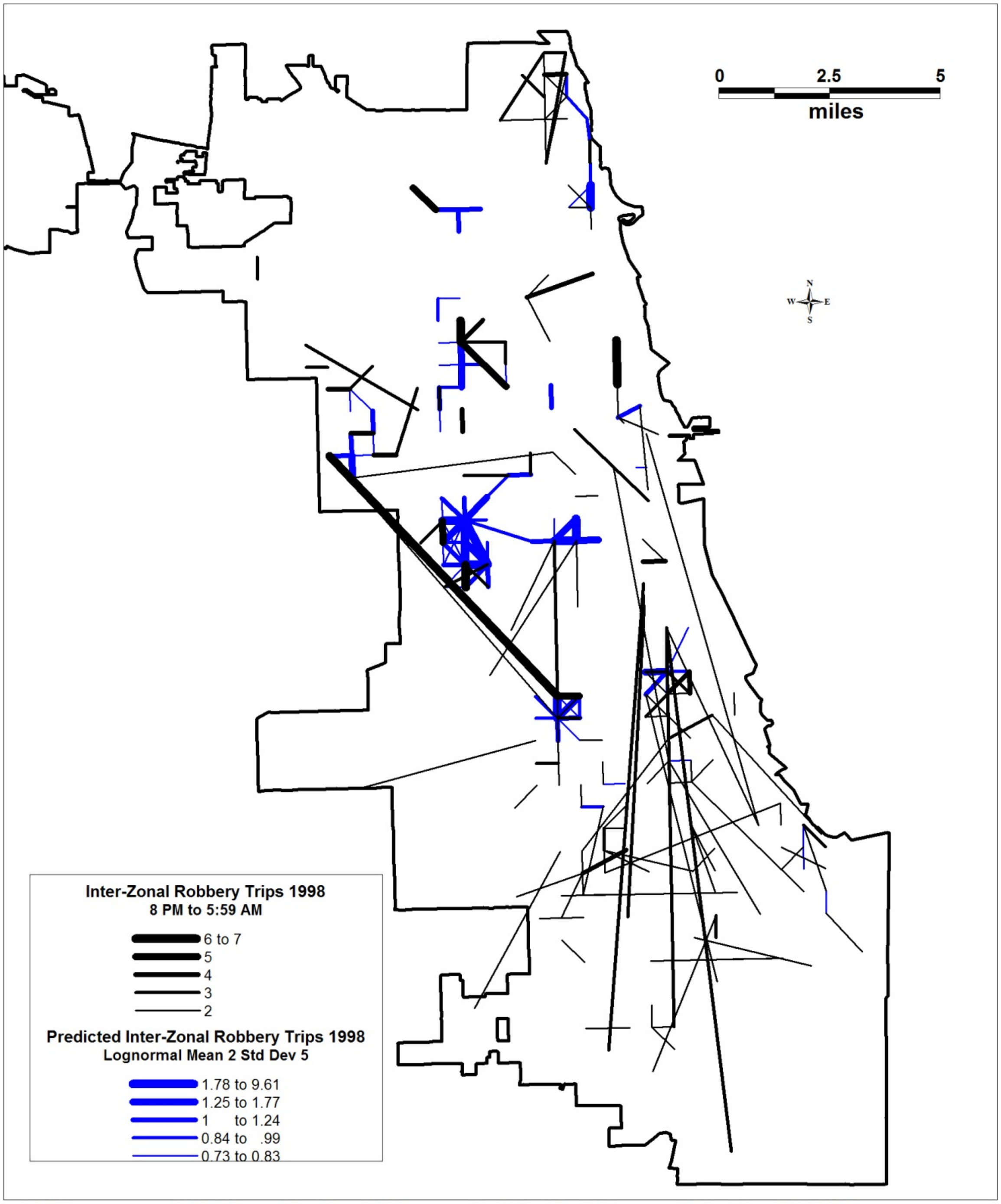
Nevertheless, to test the model, the 1997 observed robbery travel matrix was used to predict observed travel in 1998 (Figure 31.3). *CrimeStat IV*, in conjunction with a GIS and a statistical package, provides several comparison tools. Comparing 1997 and 1998, the fit was quite good. Including street segments that had no trips in either year, 55% of the trip links in 1998 were predicted by the trip links in 1997. The coincidence ratio of .86 for 1998 and the distance distribution in Figure 31.2 above indicated a high degree of similarity. However, a comparison of the top 300 trip links illustrated that, while zones with many intra-zonal incidents were fairly well predicted, inter-zonal trips were not as well predicted. Mapping these made clear that 1997 inter-zonal links did not accurately predict specific 1998 links (Figure 31.4). However, specific links may be less important from a police perspective than knowledge of the frequency of offender travel on specific streets. The coincidence ratio was about the same for both the 1997 and 1998 comparisons (Figure 31.2 for night time robbery trips).

In figure 31.3, predicted and observed overnight robbery trips in 1998 are pictured. To graphically indicate the trips, straight lines are used to indicate links between zones and widths to indicate volume. An inspection of Figure 31.3 shows that many specific links were not well predicted. In general, the prediction underestimated very short trips but overestimated middle distance trips (2-4 miles).

Predicting Overnight Robbery Trips

After selecting only those 1998 robberies that occurred from 8 PM to 5:59 AM, a zone to zone matrix was constructed. This matrix included both intra-zonal (31.5% of the total) and inter-zonal trips. As shown in Figure 31.5, zones with many intra-zonal overnight trips also had

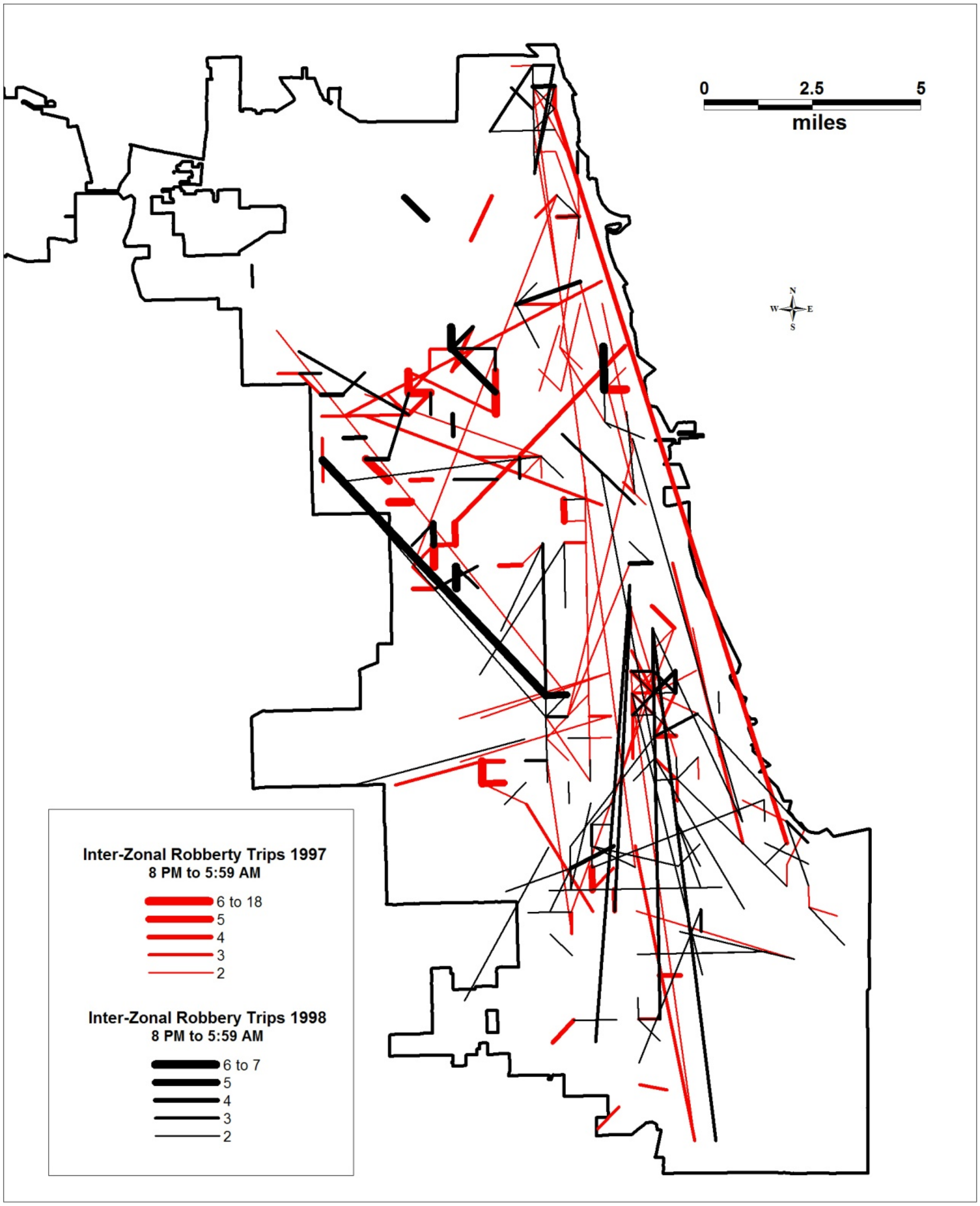
Figure 31.3



Observed & Predicted Overnight Robbery Links 1998

Source: Chicago Police Department   Cartography: Richard Block, Loyola University Chicago

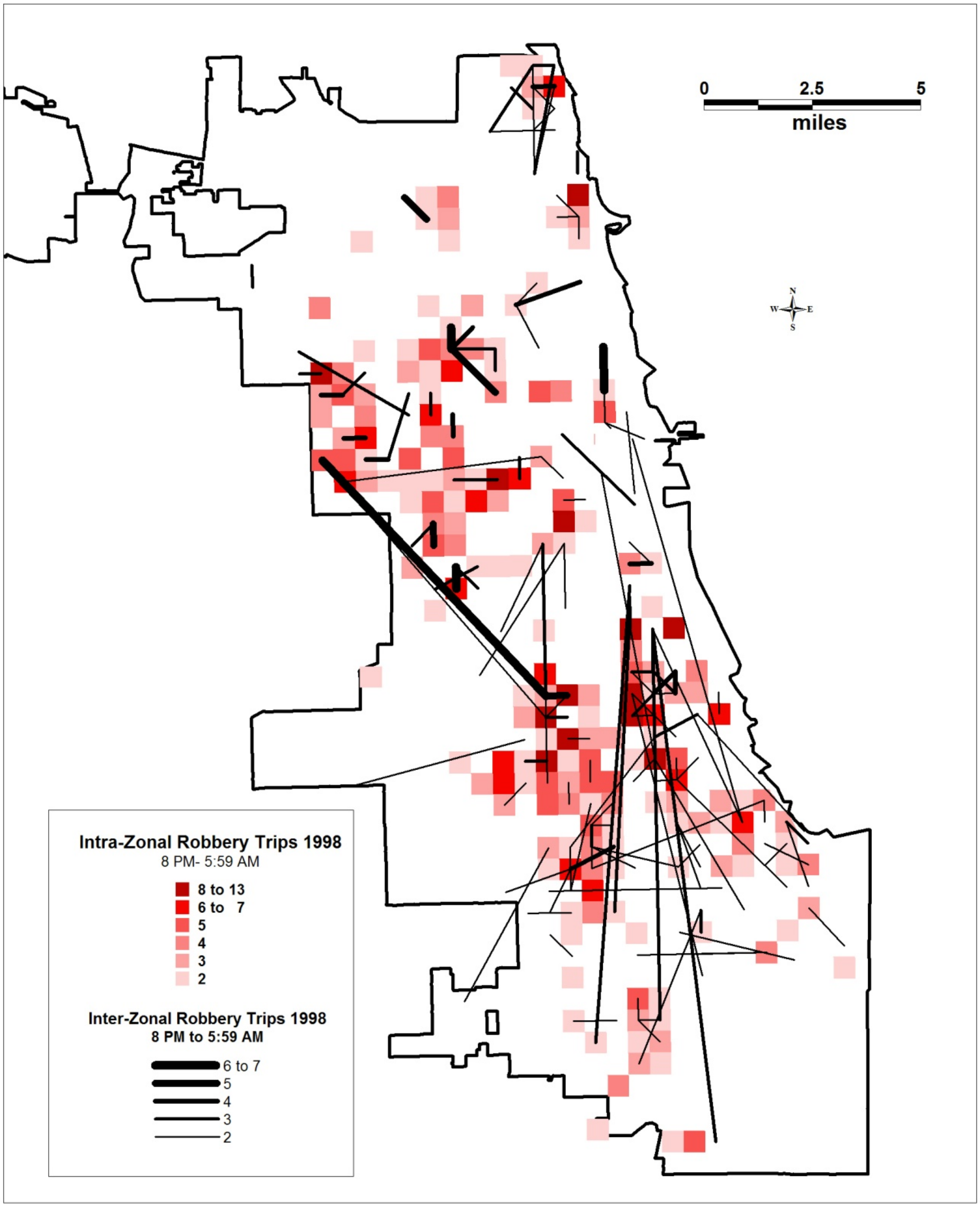
Figure 31.4:



Robbery 1998 & 1997:Observed Links

Source: Chicago Police Department   Cartography: Richard Block, Loyola University Chicago

Figure 31.5:



Robbery 1998: Overnight Intra-Zonal & Inter-Zonal Links

Source: Chicago Police Department   Cartography: Richard Block, Loyola University Chicago

many inter-zonal trips. Intra-zonal links were widely dispersed throughout the city with an area of concentration on the west side, but there was no clear pattern.

Mode Split

Because of the lack of information about travel mode, the mode split model was not run. It is hoped that, with better information, this type of model could be run in the future.

Network Assignment

The third, and final, step in the analysis was to examine the likely routes taken as well as the total demand placed on the road network. Network assignment is an especially useful tool for police work because it can suggest possible locations for intervention. Because it is based on the actual street network, it is more concrete than a depiction of links. Therefore, I tested several ways to depict network assignment for 1997 robbery travel before proceeding to the 1998 analysis.

The network assignment routine in *CrimeStat IV* outputs two results:

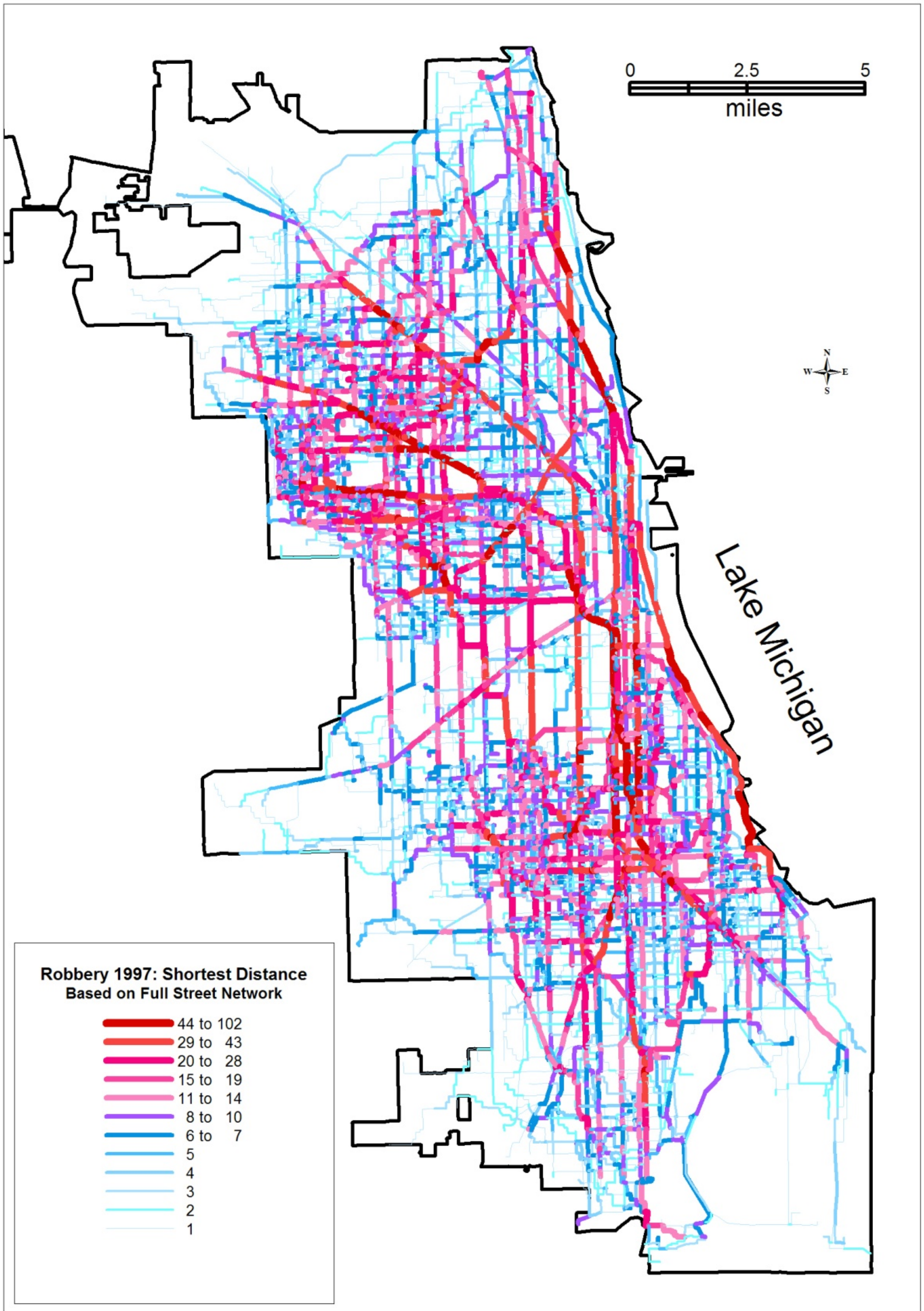
1. The shortest routes on a street network. For each zone-to-zone pair, the shortest path was calculated.

2. The Network load. Network load counts the number of trips over each street segment regardless of origin or destination and sums these.

Both the shortest routes and the total network load can be based on time or cost rather than distance.

First, all inter-zonal robberies in 1997 were mapped along Chicago's street network by shortest distance (Figure 31.6). The 4000 trips were counted along each of Chicago's 51,000 street segments and mapped as a network load (see Chapter 30). As the width and color changes from blue to red in Figure 31.6, the number of trips that passed over a segment increased. However, this map is difficult to interpret and lacks credibility. Much of the load is along small side-streets. Diagonal streets are emphasized and expressways are ignored because they usually are not the shortest route in terms of distance. Also, travel in the wrong direction on a one-way street is possible since only distance was used to calculate the shortest path. The CPD did not believe this to be a useful map.

Figure 31.6:



Robbery 1997: Shortest Distance on Street Network

Source Chicago Police Department Cartography: Richard Block, Loyola University Chicago

The same inter-zonal links were mapped again along using the Chicago modeling network, but weighting segments only by distance (Figure 31.7). While this resulted in a greatly simplified map, it still lacked some credibility. Expressways are rarely the shortest distance, therefore, their use is under emphasized. The algorithm resulted in an over emphasis on diagonal main streets. Some connected segments looked like a stair case following along Chicago's grid of main and secondary streets from one high incident neighborhood to another on the west and southwest sides.

Distance did not seem to be a good representation of travel routes. Given that police records include time of incident and travel time along Chicago's road network is available, and that *CrimeStat* allows for analysis by travel time, I re-conceptualized travel cost as shortest time rather than distance.

Shortest Time or Shortest Distance?

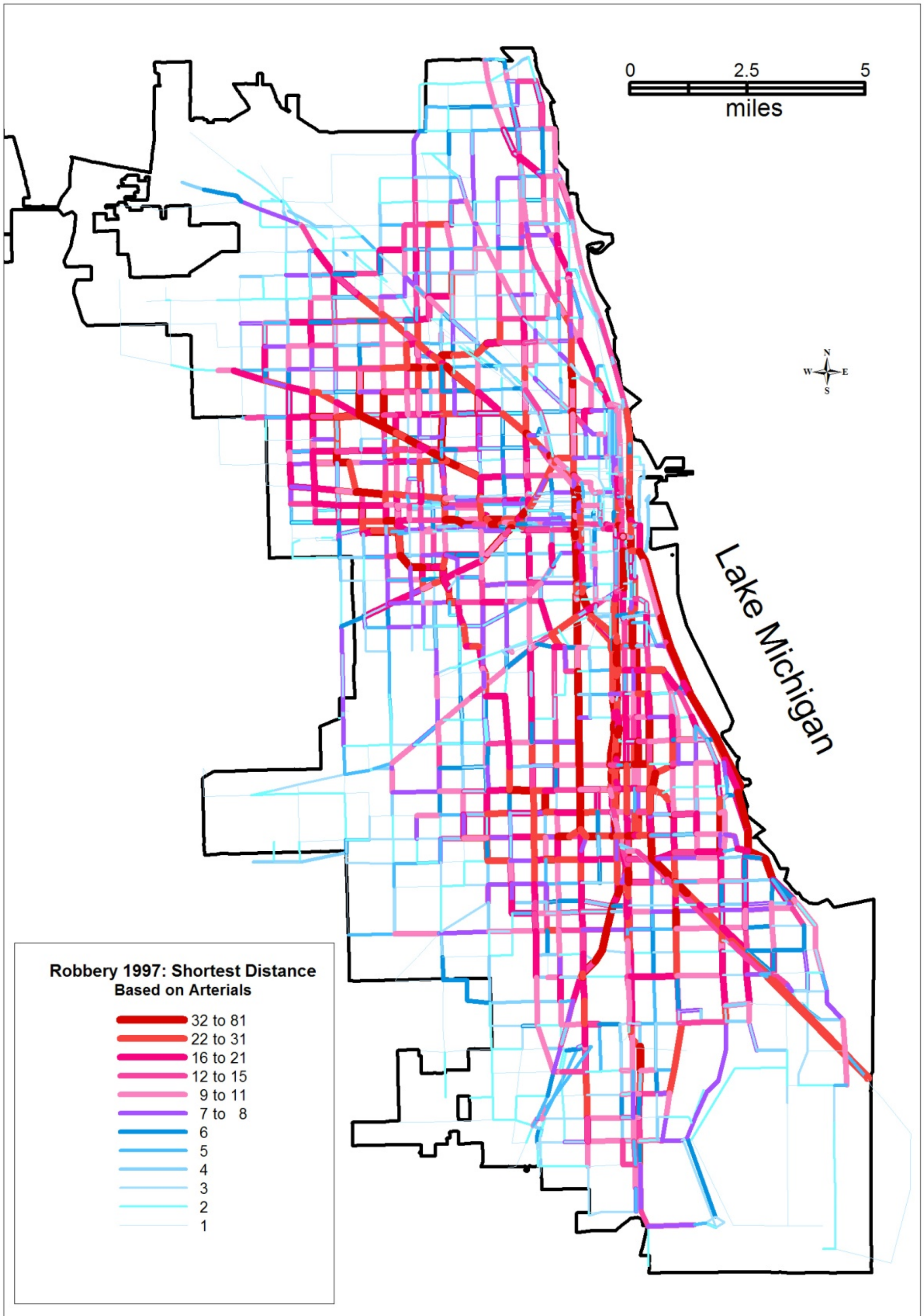
What does distance measure? Traveling ten miles during Chicago's evening rush is quite different than at midnight. However, the two blocks from my house to the nearest convenience store is unaffected by the time of day and little effected by the mode of transportation. While distance appears to be a straightforward measure, it is not. For close distances, it specifies knowledge space or the location of routine activities. Further from home, it is related to a lack of knowledge but is also an inaccurate measure of the cost of travel. Better measures than distance are often available. All U.S. major metropolitan areas map travel time by time of day on major streets, feeder streets, and expressways using modeling networks (see chapter 30). These maps along with police data on time of incident can be combined to realistically describe shortest travel time rather than shortest distance.

The Chicago Area Transportation Survey (CATS) divides the day into eight time periods based on travel demand. Whether a crime trip was intra- or inter-zonal was unaffected by time of day (χ^2=7.07 sig=.421 in 1998). Not surprisingly, the robber's daily travel cycle was different than the general population. In 1998, robbers showed little demand for travel in the morning rush hour period (6 AM to 10 AM). Of the remaining trips, about half (46% in 1998) occurred from 8 PM and 5:59 AM. These overnight trips are the subject of the analysis presented here.

Overnight robbery trip load

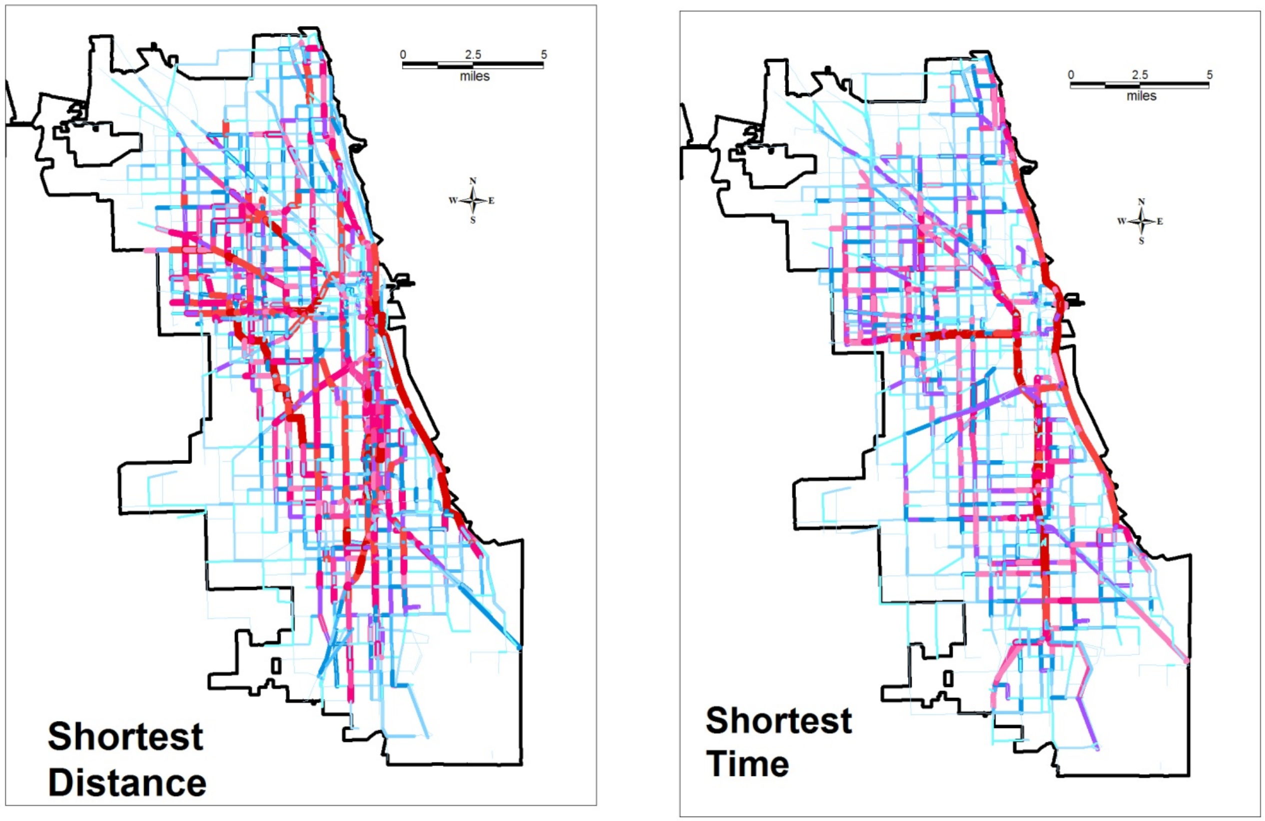
Overnight network load was mapped on Chicago's arterial roads and expressways according to both shortest distance (Figure 31.8 left) and shortest time (Figure 31.8 right).

Figure 31.7:



Robbery 1997: Shortest Distance on Arterials
Source Chicago Police Department   Cartography: Richard Block, Loyola University Chicago

Figure 31.8



Robbery 1998, Offender Travel Network for Incidents Occuring from 8 PM to 5:59 AM. Shortest Travel Time & Distance Compared

The two maps are very different. Expressways are rarely included in the shortest distance between zones. Much of the travel is on diagonal surface streets. However, if travel time is taken into account, many of the trips are on expressways and on Lake Shore Drive. This is probably a more realistic description of longer distance trips.

In moving from a complete street network to a simplified network using distance as an impedance to a time-based network, the description moves from an unrealistic and probably un-interpretable map to one that probably corresponds to the routes taken by offenders. Does this add to police knowledge? Of the 10,763 mapped segments in the network, 65.1% had no predicted trips assigned to them. Two percent of the road segments, those with 15 or more trips, contributed 20.2% of the 16,162 robber's movements across road segments. These were typically arterial roads or expressways. By identifying these streets as those most likely to carry crime trips, these ‘hot street’ segments could become a focus for police patrol or for intervention to prevent crime.

Conclusions

Feasibility & Advantages of Crime Travel Demand Modeling

The police already collect information on the location and time of incidents and the home address of arrested offenders. Can this information be utilized to describe and predict the travel patterns of Chicago robbers? *CrimeStat*'s trip distribution module was used to describe zonal patterns of travel for all known 1997 Chicago robbery offenders. Around 30% of Chicago robberies were committed near to the offender's home. For these a zonal model cannot predict travel patterns. For other robberies, a time-weighted travel pattern resulted in a more credible description than one based on distance.

The key to analyzing the robber's travel pattern is to reconsider the meaning of distance. Close to home or work, distance represents a knowledge space and an opportunity space, a place the offender knows in which he or she spends a lot time. This is an area where the benefits of knowledge may outweigh the costs of possible capture or it may simply be where the offender hangs out.. Further away, shortest distance is a poor representation of travel cost. In major metropolitan areas, a better representation is shortest travel time. Combining travel time of day with time of incident, results in a more realistic travel pattern.

These intra- and inter-zonal links are a new way to look at the relationship between offender and incident. However, they need some representation before they are useful to the police for tactical analysis or crime prevention. In my discussion with the Chicago Police

Department, a network load map seemed to be most useful. Network load summarizes the number of crime trips that passed over each segment in a road network.

Limiting analysis to robberies occurring overnight (8PM to 5:59 AM), 1997 travel patterns were a good predictor of travel distances, intra-zonal robberies, and network load in 1998. However, 1997 travel patterns only weakly predicted specific links between traffic analysis zones. For 1998 incidents, a trip distribution model (using Poisson regression of the zonal count of robbers' homes and incident locations, and an impedance function) modeled the overnight travel links between home and incident. Substituting a lognormal impedance function that better matched the observed overnight robbery pattern resulted in predictions that were nearly as good as the 1997 observed travel patterns. A combination of these predictions with analysis of travel patterns over several years might eventually result in an excellent zonal prediction of crime travel patterns.

Crime travel demand analysis is complex and time consuming and requires a relatively powerful PC with a large memory capacity. Is it worth it? Yes. Information on crime trips is automatically gathered by the police, but it is not fully utilized. However, unlike transportation planners, police are generally concerned with the short term and with acute rather than chronic problems. They work on an existing street network rather than planning for the future. Crime travel demand models may better serve the police as short term descriptions rather than long term predictions and can probably be used to describe the effect of specific police interventions such as road blocks or drug interdictions. The crime travel demand model along with a GIS can identify hot street segments–those segments that are most likely to be on the travel routes of offenders and most useful for intervention to prevent crime.

For researchers, on the other hand, a crime travel demand model is a good way to ask long-term, structural questions. If the travel patterns remain relatively constant over time, then these relationships can be modeled using a limited number of variables. The result is a way to compare different metropolitan areas as well as a way to look at the same metropolitan area over different time periods. It is a framework for analysis that is broader than just a journey-to-crime type of description.

Limitations to Crime Travel Demand Modeling

There are also limitations to the model:

1. Only crimes with at least one known offender are analyzed. To the extent that offender travel patterns in unsolved crimes are different than those with known offenders, travel patterns will be misrepresented.

2. The model works best if records are gathered in such a way that the address of an offender home can be linked to the address of an incident.

3. The travel demand model assumes that the offender's home address is accurate. Offenders may not have a stable address or may give a false address.

4. The travel demand model assumes that offenders travel directly from home neighborhood to incident neighborhood; many probably do not.

5. The crime travel demand model is an aggregate model, not a individual one. It predicts travel from the center of one zone to the center of another. It cannot predict specific trips or the behavior of specific offenders and cannot predict travel within a zone.

6. The model must be crime and city specific. Chicago robbers were much more likely to attack close to home than those in Baltimore County (Chapter 28) or Las Vegas (Chapter 32). Because these homes were distributed throughout the city, the travel patterns of Chicago robbers were much less focused on single target zones than in the other test sites.

7. The study of Chicago was limited to incidents that occurred in the city of Chicago. It does not model travel patterns of incidents occurring outside the city and can say nothing about them.

8. The data available from the Chicago Police Department did not allow for a test of travel mode used. It cannot be assumed that criminal trips use the same modes of transportation as non-criminal trips.

Chicago is a city of isolated neighborhoods. Even nearby neighborhoods may be *terra incognita*. Crime travel follows the pattern of neighborhoods. In Chicago, many robberies occur very close to the home address of the offender. The crime travel demand model cannot analyze these crime trips because each zone is represented by a single point. In some impoverished neighborhoods, robbery is very common. An offender can opportunistically attack on any block. Even when offenders travel they tend to stay nearby their home neighborhood. The isolation of robbery in the a few neighborhoods results in a downtown that is relatively free of incidents and crime trips that are relatively short.

Chicago is a mature city. Neighborhoods change slowly. Large scale changes in housing, poverty, or attractors do occur and include the destruction of public housing, widespread gentrification and the replacement of rail yards with upscale housing. With these changes come new opportunities for crime and changing crime travel patterns. These may be predicted with the crime travel demand module.

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