

Chapter 32:  
**Case Studies in**  
**Crime Travel Demand Modeling II:**  
**Application of Travel Demand Behavior Model to**  
**Crime Data from Las Vegas, Nevada**

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**Chapter 32:**  
**Case Studies in**  
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**II - Application of Travel Demand Behavior Model on**  
**Crime Data from Las Vegas, Nevada**

In this chapter, a case study of crime travel demand in Las Vegas, NV is discussed. Originally written in 2004, it is presented in order to illustrate how crime travel demand modeling can be applied to a primarily auto-oriented city.

**Introduction**

Strategic crime forecasting has for many years relied on a limited and simplistic suite of methods to predict approximately where future events may occur in broad strokes. Extrapolation of percentile change is probably the most commonly used means of forecasting future crime frequencies, based on the notion fundamental to all predictions, that the future will resemble the past. Unfortunately, this method is completely unable to cope with changes in the demographics, population, and social makeup of a jurisdiction.

For a number of years, innovative crime analysts and criminologists have looked to other disciplines outside the study of criminal behavior for methods of predicting how the future will unfold. Economics, epidemiology, meteorology, and biology have all offered significant contributions as their more sophisticated and creative methods for foretelling future frequencies have been adapted to criminology with varying degrees of success.

Transportation modeling is the most recent external science to suggest potential means of predicting criminal behavior. The success of travel demand modeling in the civilian world of transportation behavior has presented us with another possible technique which could be adapted to forecasting crime. Travel demand modeling offers a set of algorithms for estimating not only how much activity will occur in a given region, but also how offenders will travel across the jurisdiction to commit their crimes. This model has been implemented in the *CrimeStat* software application for use against crime data.

In this study, we will review the application of this model against data from the metropolitan Las Vegas area over a period of three years.

## **The Las Vegas Metropolitan Area**

The Las Vegas metropolitan area is comprised of Clark County, Nevada, and several independent municipalities within it. The Las Vegas Metropolitan Police Department (LVMPD) serves Clark County (in the capacity of a Sheriff's Office) as well as the City of Las Vegas (in the capacity of a municipal police department). Although the vast majority of the land area, population, and businesses within this area are policed by the LVMPD, there are three other significant jurisdictions - the City of North Las Vegas, the City of Henderson, and the City of Boulder City, each having their own police department.

In addition to these important sibling agencies, several other law enforcement agencies have overlapping jurisdiction within areas principally policed by the LVMPD - the Paiute Tribal Police, the Southern Pacific Railway Police, the Nevada Highway Patrol, U. S. Air Force Security Police, U. S. Air Force Office of Special Investigations, Federal Bureau of Investigation, Veteran's Administration Police, and others. Although these agencies perform valuable police functions, the LVMPD unquestionably deals with the vast majority of crime in the area, making it an attractive candidate for offender travel research.

In many ways, Las Vegas resembles an island. Surrounded by barren desert, with very few roads entering or leaving the city, it is an urban oasis in a sparsely populated desert wilderness consisting of largely impassable terrain. This geographic position and isolation make Las Vegas highly interesting from the perspective of a transportation (or crime trip movement) modeler.

Another unique feature of the Las Vegas area is the highly transient nature of the population, which falls into three discrete categories:

1. First, the resident population consists of some one million persons, approximately 880,000 of which live in the jurisdiction of the LVMPD (the remainder being served primarily by Henderson and North Las Vegas). These permanent residents are the mainstay of the community and the source for demographic data used by the census bureau and planning agencies.
2. Second, we must consider the visitor population, consisting of some 35,000,000 - 40,000,000 persons per year. On any given day, between 100,000 and 500,000 visitors will be staying in the Las Vegas area, a critical factor in transportation, demography, and crime! These tourists sometimes act as crime importers (e.g., criminal street gangs from neighboring Californian cities often visit Las Vegas for weekend mayhem or more professional criminal purposes); in most instances, however, they serve as a pool of prey for local criminals.

3. Third, and finally, there is a substantial homeless population in Las Vegas, drawn by the seasonally warm climate and the ease with which this city can be reached as a destination. Although not famous for a "friendly" attitude toward the homeless, these persons are protected by law enforcement in Las Vegas and are well served by many charitable social institutions and services. Because Las Vegas is also an easy place to sin, homeless individuals with drug, alcohol, and gambling addictions often gravitate there; the possibility of "winning big" and instantly reversing a life of misfortune also weighs in the consideration of many homeless who choose to make their base in Las Vegas. However, due to the inability to accurately measure a "home" location for these persons when they do commit crimes, few of these have been represented in this study.

This study will focus on the criminal movement behavior of the resident population of the greater Las Vegas metropolitan area.

## **Source Data Provenance and Organization**

Data concerning the Las Vegas metropolitan area was provided by the Las Vegas Metropolitan Police Department's Investigative Division. Often, researchers underestimate the severe difficulties and chronic shortcomings of law enforcement data. Thanks to a first-rate records management system (RMS) and a voluminous tactical database repository, the Las Vegas Metropolitan Police Department's data presented relatively few problems; however, geocoding accuracy issues, missing data fields from *modus operandi* tables, and erroneous arrestee home locations result in sources of error that can contaminate analysis. These had to be overcome before any analysis or testing of new methods was possible.

Crime report data for the LVMPD is maintained in an SQL-Server 7.0 database constructed by the Printrak (now owned by Motorola) company, makers of the Law RMS (LRMS) police records management system used by Las Vegas, among others. This repository currently houses many hundreds of thousands of crime reports, field interviews, and other critical police data in a well-organized, relational database.

Crime reports are filled out by either sworn officers (when taken in the field) or by station personnel (when reported in person at an LVMPD substation or city hall). These paper reports include ample MO detail and descriptive information in compartmentalized, "force-choice" fields, as well as substantial expository narratives. "Forced-choice" fields are also typically supplemented by "Other" options which can then be individually explained, to deal with very unusual crime behaviors, descriptions, or details.

At the end of each shift, officers submit their reports to their sergeant for review. After a quick check to ensure the most basic levels of data quality and integrity, the reports are then placed in a mailbox for pickup, which occurs several times each day and night. Reports are transferred by intradepartmental couriers to city hall where they are collected by the Records Section. Professional data entry specialists then meticulously type each report into the LRMS database.

The data entry process includes several validation and error trapping elements. These usually greatly enhance the completeness and accuracy of each report, but are sometimes bypassed by busy clerks. Perhaps the most significant validity check which can be bypassed is the address verification system which performs a 'brute force' match against a geofile of known, valid locations. When a matching address is entered into the system, geographic coordinates and other useful data is automatically propagated into the file. Because many crimes do not occur at valid, documented physical street addresses (crimes in remote or desert areas or in new construction zones or on buses or in taxi cabs, for example), however, data entry clerks have grown accustomed to overriding the address verification module. This is also sometimes done in the interests of speed and expediency, even when a valid, matchable address is provided in the crime report. When this happens, the resulting address must be cleaned using a data cleaning application prior to successfully matching in a geocoding operation. Once entered into the LRMS database, crime report information may be extracted through a variety of standard methods.

The LVMPD routinely downloads crime reports on a daily basis into an ATAC analytical database where crime analysts and investigators can examine and study the data without creating any drag on the primary server. The ATAC database is streamlined for analysis, and is much easier to query and analyze than the LRMS repository itself. The ATAC databases are Microsoft-compliant relational databases very similar to the MS Access database.

Data used for the Next-Generation Offender Crime Travel Model project were derived from records stored in several ATAC analytical databases created and maintained by the LVMPD Crime Analysis Section. These databases are archived by calendar year and by crime category. The archive dates for calendar year are assigned based on the year of occurrence. Crime categories are: auto crimes (including motor vehicle thefts, burglaries from motor vehicles, and criminal damage to automobiles); burglaries (including all burglary statutes); Larcenies (including all Larceny/Theft statutes); and personal crimes (including all sexual offenses, assaults and aggravated assaults, robberies and home invasions, kidnappings, and homicides).

These databases contain MO, Persons, and Vehicles tables related by event number. The MO table contains all information pertinent to the location, timing, category, and methods of each crime event; the Persons table all information on personal identification, description, and

histories, not only for suspect and arrestees, but also victims, witnesses, reporting parties, etc.; the Vehicle table all information concerning any vehicles which may be involved in the offense, including descriptive and identification information, whether the vehicle relates to the criminals, victims, or has some other relationship to the crime.

For purposes of this project, the LVMPD authorized access and transmission of the contents of the complete ATAC database inventory for the Crime Analysis Section. Of the fifty-odd databases provided, the Personal crimes databases for the years 1996 - 2002 were initially selected.

### **Data Screening**

Three broad categories were selected from the complete data inventory provided:

1. Confrontational
2. Burglary, and
3. Vehicular crimes.

These intentionally disparate data were selected in the interests of increasing the latitude of the study. It was hypothesized that travel behavior would vary between these categories of events. Confrontational crimes included sexual assaults, robberies, kidnappings, and murders. These crimes were included in a single group as part of this initial appraisal of the effectiveness of travel demand modeling on criminal behavior even though it is obvious that the behaviors exhibited by offenders across these crime types are likely to vary. These crimes were grouped in spite of these likely differences because similarities in targeting behavior across these crimes might make them amenable to collective analysis; a hypothesis which can be tested using the techniques built into the travel demand module.

Burglaries used in this analysis included both residential and commercial burglaries, but not burglaries from motor vehicles. Only crimes in which a building or property was illegally entered for the purpose of theft were included in this study, thereby eliminating the prolific larceny category.

Vehicular crimes included both auto thefts and burglaries from motor vehicles. "Carjackings" were not specifically included, but some auto thefts in which the modus operandi followed the confrontational "carjacking" pattern may have been included when specifically statutory designations were missing to differentiate these from more typical auto thefts.

Some operational definitions of these crimes are in order:

1. Sexual assaults used in this analysis included forcible rapes with victims of either sex, as well as any other physical, sexual abuse of another person of either sex - such as digital or objective penetration, fondling, etc. - and also open and gross lewdness (e.g., "flashing"). Statutory sexual seduction ("statutory rape") was excluded.
2. Robberies used in this analysis included all robbery-related statutes in the Nevada Revised Statutes as of 2002 including home invasions (see State of Nevada, 2012).
3. Kidnappings were included in confrontational crimes, but the application of kidnapping as a statutory offense by law enforcement in Las Vegas (and elsewhere) may be counter-intuitive to some readers. Kidnapping is often attached as an additional offense to other crimes, such as robberies or sexual assaults, in any case in which the victim is forcibly moved from one location to another. This practice is used primarily as an adjunct to prosecution because kidnapping (unlike either robbery or sexual assault) is a federal crime and, in some cases, may be easier to prove in court.
4. Homicides used in this analysis included all murder statutes, as well as all manslaughter statutes. No justified homicides were included.

Once the target crime categories had been defined, separate databases for each of the three categories were compiled. Although data for several years was made available, all but three years of data were excluded from the study. Data prior to 1997 was often relatively poorly maintained and prepared and sometimes contained serious omissions which made it unreliable. Data for the year 2002 was incomplete when this study was commissioned. Although crime data for the years 1997 and 1998 was functionally reliable, socio-economic and transportation data for these years was not readily obtainable at the time this study commenced; since these data were necessary for implementation of this model, these years, too, were excluded from analysis. Therefore, only the years 1999, 2000, and 2001 were included in this study.

Because this study focuses on spatial relationships between crime event locations and criminal home locations, only solved crimes could be used. Crimes were included as "Solved" when an arrest was made - unfortunately, difficulties in obtaining data from the justice system and the long delays inevitable in the prosecutorial process made it impossible to identify crimes in which a conviction had been obtained; an arrest was the closest approximation to a reliable solution possible for this research.

Of those "solved" crimes in which an arrest was made, only those in which the offender's home address and the precise location of the crime itself were both known could be used. Even when crimes were closed by arrest and adequate data was available to geographically plot and analyze the case, some have still been excluded. Instances in which the offender and victim both live at the scene of the crime have been excluded from these analyses since no travel was involved. However, instances in which either party lived at the scene of the crime but the other did not have been retained. The reasoning behind this decision is that the decision to commit a crime at a given place does include the decision to commit a crime in one's own home. Therefore, the spatial travel (none) component of this decision should still be reflected in the model if we hope to eventually derive a valid statistical representation of offender travel behavior.

Also, crime in which the offender lived outside the study area (Clark County, Nevada) have been excluded in most cases, but not all. In some cases, "tourist" offenders may have been included when their temporary "base of operations" (i.e., local lodgings) had been recorded. In these instances, the hotel, motel, resort, or private dwelling they lived in has been used as a "home" location for purposes of originating a crime trip.

The number of cases usable for each category of crime varied significantly from year to year (Table 32.1).

**Table 32.1:  
Confrontational Crimes Available for Analysis**

<u>Year</u>	<u>Total Offenses</u>	<u>Usable Offenses</u>
1999	5,272	1,080
2000	7,560	1,643
2001	3,588	991

The large increase in number of offenses from 1999 to 2000 is difficult to explain; the following substantial drop from 2000 to 2001 (52%!) is even more troubling. A similar, but inverted, discrepancy emerges in the frequency of burglaries reported during those years (Table 32.2).

**Table 32.2:  
Burglary Crimes Available for Analysis**

<u>Year</u>	<u>Total Offenses</u>	<u>Usable Offenses</u>
1999	17,234	2,520
2000	12,899	2,040
2001	16,403	2,733

A final enigma, most significant of all, is obvious when we look at the frequency of auto crimes over the same three-year period (Table 32.3).

**Table 32.3:  
Vehicular Crimes Available for Analysis**

<u>Year</u>	<u>Total Offenses</u>	<u>Usable Offenses</u>
1999	6,871	646
2000	15,025	1,219
2001	8,349	894

These disparities are hard to account for. On the whole, 1999 had a middling number of auto thefts and confrontations but a high number of burglaries; in 2000, on the other hand, the confrontations and auto thefts radically increased (auto crimes more than doubled!), but burglaries dropped notably. Finally, in 2001, confrontational crimes dropped to the lowest levels as did auto crimes while burglaries leaped to nearly 1999 levels!

How can we explain these strange fluctuations? Given the large percentages involved, it's tempting to imagine some change in counting or reporting procedures in 2000; however, a scrutiny of the policies and procedures for the LVMPD does not seem to bear this out. Previous years (1996 - 1999) did not evince a similar wide degree of variation. The reason for these crime reporting changes remains unknown.

Is there reason, therefore, to distrust these data? For purposes of this study, the answer appears to be, "No." That is, the data used for these analyses should, even allowing for as yet-unexplained vagaries in reporting, comprise a representative sample of the reported crime activity in Las Vegas over these years.

Since forecasting the frequency of crime is a relatively minor component of the travel demand model, these numeric variations should not cause too much concern. Instead, since the focus of this model is the effective explanation and representation of the distribution of crime

trip generators and crime trip destinations (and, as a function thereof, of the crime trip paths between them), the frequencies themselves should matter little.

### **Reference Data**

The Traffic Analysis Zone (TAZ) file for Las Vegas was selected as the optimum polygonal reference theme for this study (Figure 32.1). This file was provided by the Metropolitan Planning Office for Las Vegas, the Regional Transportation Commission. The data provided included historical data for 1999, 2000, and 2001 enabling more accurate modeling of the importance of various factors longitudinally across time. The TAZ dataset was provided in ESRI shapefile format, which is intrinsically legible to the CrimeStat application on which the model is to be built.

The TAZ shapefile includes information on housing, employment, income, population, road mileage, and a variety of subset data specific to particular types of employment (e.g., "Strip" jobs, Nellis Air Force Base employment, entertainment-related jobs, vacant properties, number of pawn shops, etc.).

An additional reference theme was needed to apply the final step in the travel demand model, the network assignment method. The Major Street Centerline file (LVMAJSCL.shp) in ESRI shapefile format was selected (Figure 32.2). Although only including arterial streets, freeways, and major thoroughfares, this transportation network layer is all that is needed to describe the vast majority of trips (of any sort) in Las Vegas. The addition of bus route information may prove a useful supplementary network to future analyses using this model.

### **Assignment of Crime Trips**

Data from each year, by category, was assigned to a simple tabular database consisting of an identifying variable (Event Number as primary key), origination coordinates (coordinates of the offender's home address, or local base of operations in the case of external offenders), and destination coordinates (coordinates of the crime scene). These data were then combined into an *MS Access 97*<sup>®</sup> database for analysis using CrimeStat. Figures 32.3 and 32.4 show the assigned origins and destinations.

Each origin-destination pair is termed a "Crime Trip." Following the reasoning of transportation modelers, it is understood that offenders do not leave their homes, travel directly to a crime scene to commit an attack, and then return home. Instead, each "sortie" is likely to consist of several stages.

Figure 32.1:

## Traffic Analysis Zones in Las Vegas

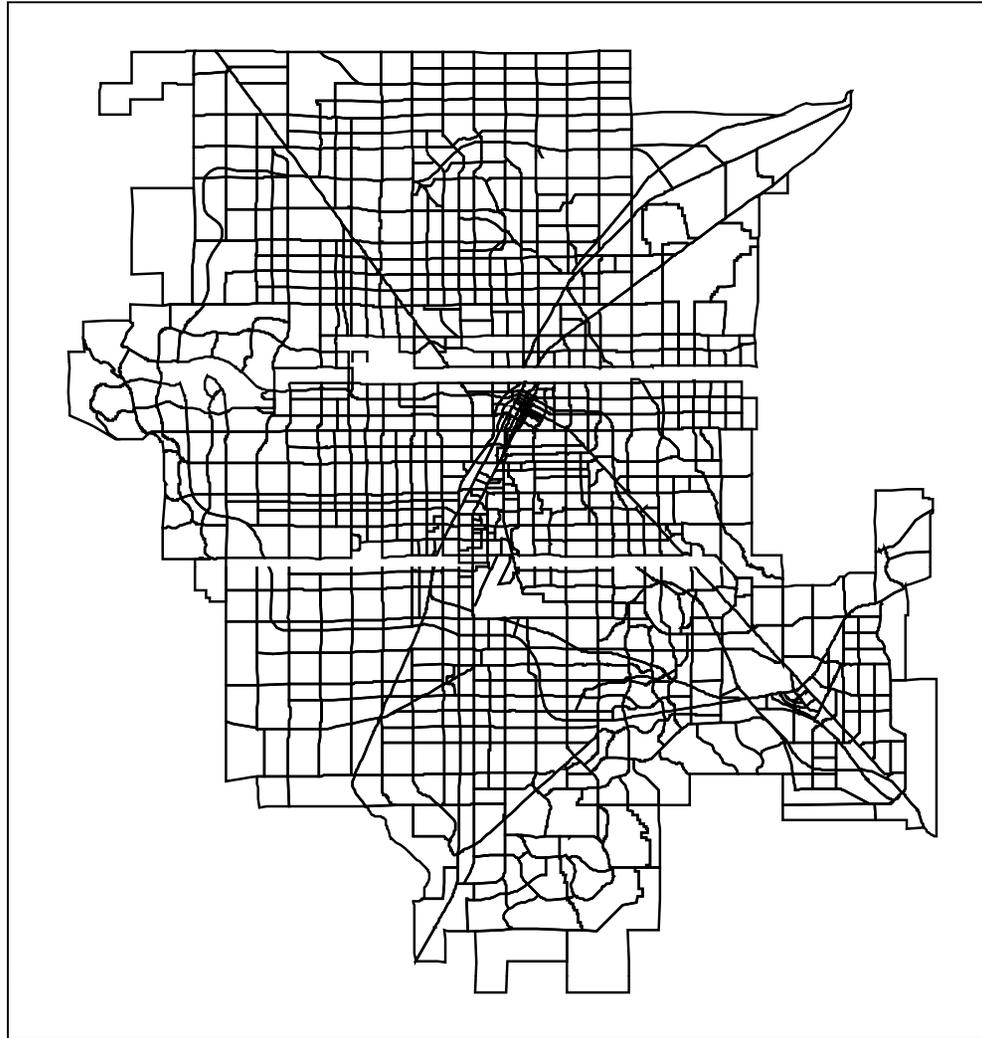


Figure 32.2:

# Las Vegas Major Street Centerline Network

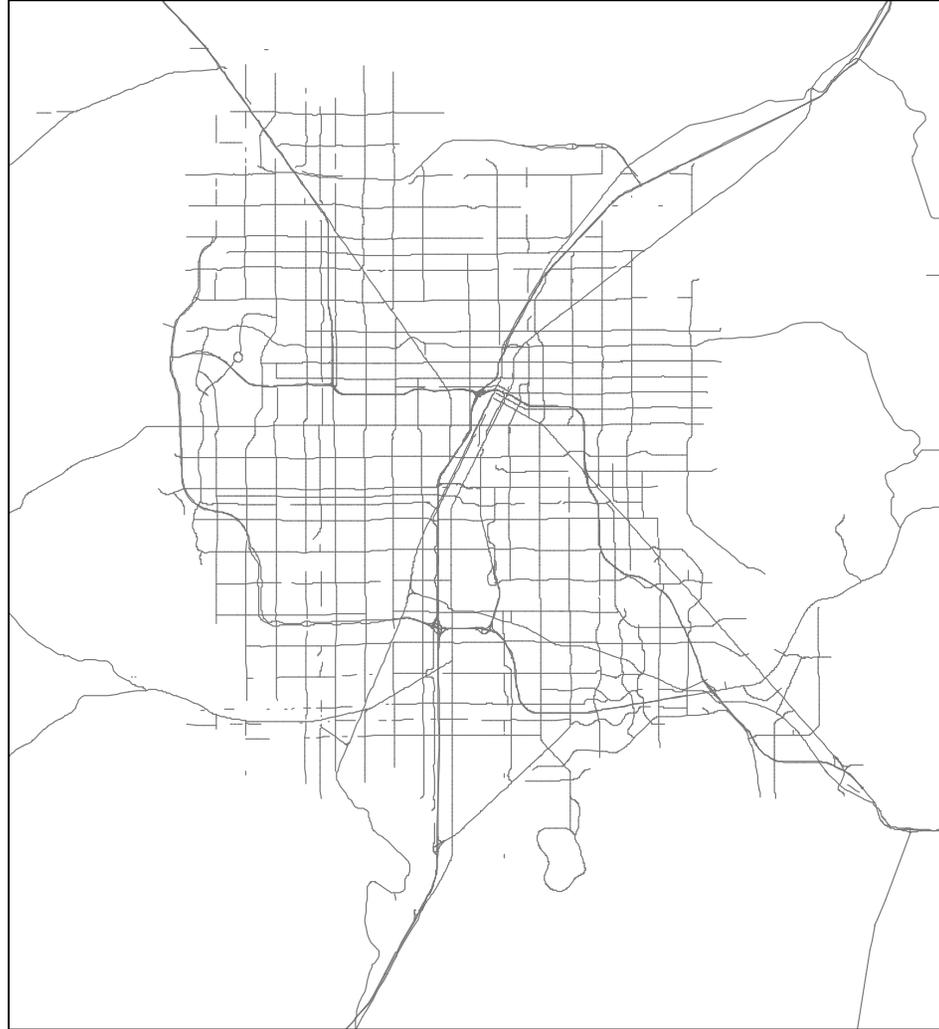


Figure 32.3:

## Trip Origins: All Confrontational Crimes, 1999-2001



Figure 32.4:

# Trip Destinations: All Confrontational Crimes, 1999-2001



For example, a sexually predatory offender may get up in the morning, leave home, drive to work (stopping for coffee along the way), then go out to lunch before returning to the office, then on his way home depart from his usual route to drive through a residential neighborhood, looking for targets for potential victims. If a promising target is observed, he may then commit an attack, then drive back toward his home area, stopping off for gas or at a drive-through restaurant on the way, before parking at his house. Although this round-trip from home to home consists of multiple destinations, some of which are repeated throughout the day, the whole journey is considered to be a single "Crime Trip".

In some cases, a single offender was responsible for many crimes. When this happens, the single origin is paired with multiple destinations, resulting in separate Crime Trips. In other cases, one crime may be perpetrated by multiple offenders. When this happens, each offender's origin is paired with the single destination, again resulting in separate Crime Trips.

While it is possible to distinctly model each Crime Trip based on precise spatial locations, the type of model used is an aggregate one. Thus, both origins and destinations of each crime trip were aggregated to the centroid of each Traffic Analysis Zone. This enables the spatial assignment of TAZ variables such as income and population to the aggregate frequencies of both origins and destinations.

This assignment is performed in CrimeStat by centroid allocation - the nearest TAZ centroid is used to assign the TAZ data to each origin and destination. This method is faster and simpler than "point-in-polygon" spatial aggregation and assignment, but should result in comparatively few mistaken assignments due to unusual TAZ polygon shape or distribution. Since crime trip data is aggregated to the zonal level, therefore, the resulting analyses and forecasts are only applicable to this level and cannot meaningfully disaggregated to a more refined resolution.

The accepted travel demand model framework contains a built-in "error factor" for external trips - that is, crime trips originating outside the study area but having internal destinations. These "external trips" were culled from the crime database during the data screening process; therefore, "External Zone" data is inapplicable to the trip generation stage of the analysis.

## **Trip Generation**

Each origin/destination pair having been aggregated to the TAZ polygon layer, it is now possible to evaluate the relationship between socio-economic variables available in the TAZ database with the frequency of crime origins and destinations. This is accomplished through

regression modeling and may prove one of the most useful single features in the new modeling capabilities of the *CrimeStat* application.

There are two main regression options available in the software at present: Ordinary Least Squares (OLS) and Poisson.<sup>1</sup> The Poisson estimation also includes a separate option which allows backward elimination of variables. This option, Poisson Regression with backward elimination, was the most effective of the techniques evaluated resulting in consistently better visual fits to the data and lower residuals. This very useful step examines each variable element suggested by the analyst for its predictive value as a coefficient in estimating the frequency of either origins or destinations by TAZ.

In every case, three variables within the TAZ database for Las Vegas proved consistently useful as predictive measures:

1. Income,
2. Population, and
3. Total Employment.

The measurable successfulness of these variables to account for the predictable distribution of both origins and destinations was somewhat counter-intuitive. It was suspected prior to the application of this model that other variables would be critical predictors of crime, in particular the number of pawn shops, the number of Strip employment opportunities, and the number of Nellis AFB employment opportunities. In fact, however, all of these variables demonstrated strong multicollinearity with the three primary variables listed above. When these other, extraneous factors were excluded from the regression process, the effectiveness of the model's predictive capabilities was substantially improved.

A suggested and accepted travel demand modeling techniques widely implemented by transportation planners is the adoption of "special generator" variables to explain unusual or unique factors implicit in some areas. It was expected that Nellis AFB, the Las Vegas Strip itself, and some other seemingly significant factors would likely fill the role of "special generator;" however, results indicated that none of these were as effective in a predictive or explanatory role as income, population, and total employment.

Latitudinal forecasting of crime trip origins and destinations performed fairly well; comparison of expected versus observed trip numbers did not match particularly well but the relative distribution by TAZ was a very close match (Figures 32.5 through 32.8).

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<sup>1</sup> Since this was first written, the regression capabilities have been expanded to include a variety of Poisson-type models including Poisson-Gamma, Poisson-lognormal, and Conway-Maxwell Poisson all with a spatial component. See Chapter 20.

Figure 32.5:

## Relative Distribution of Observed Crime Trip Origins

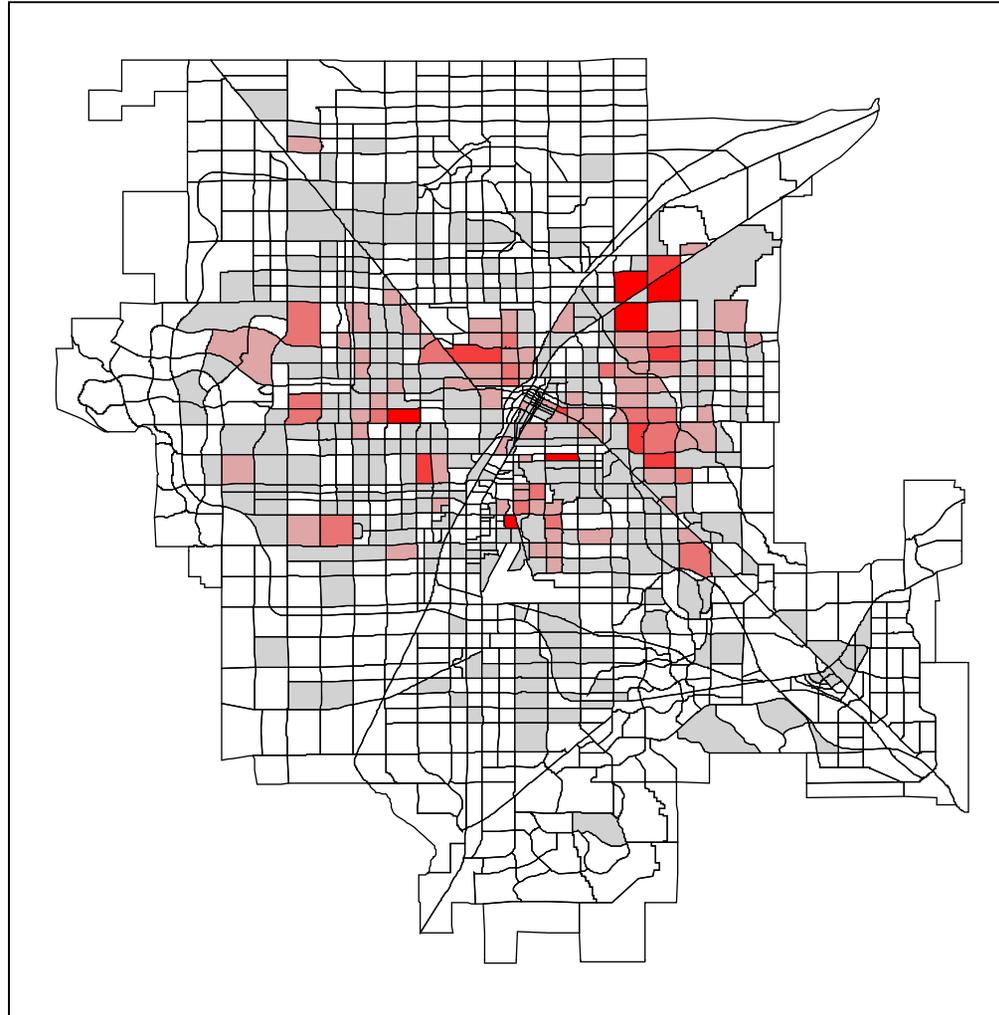


Figure 32.6:

# Relative Distribution of Observed Crime Trip Destinations

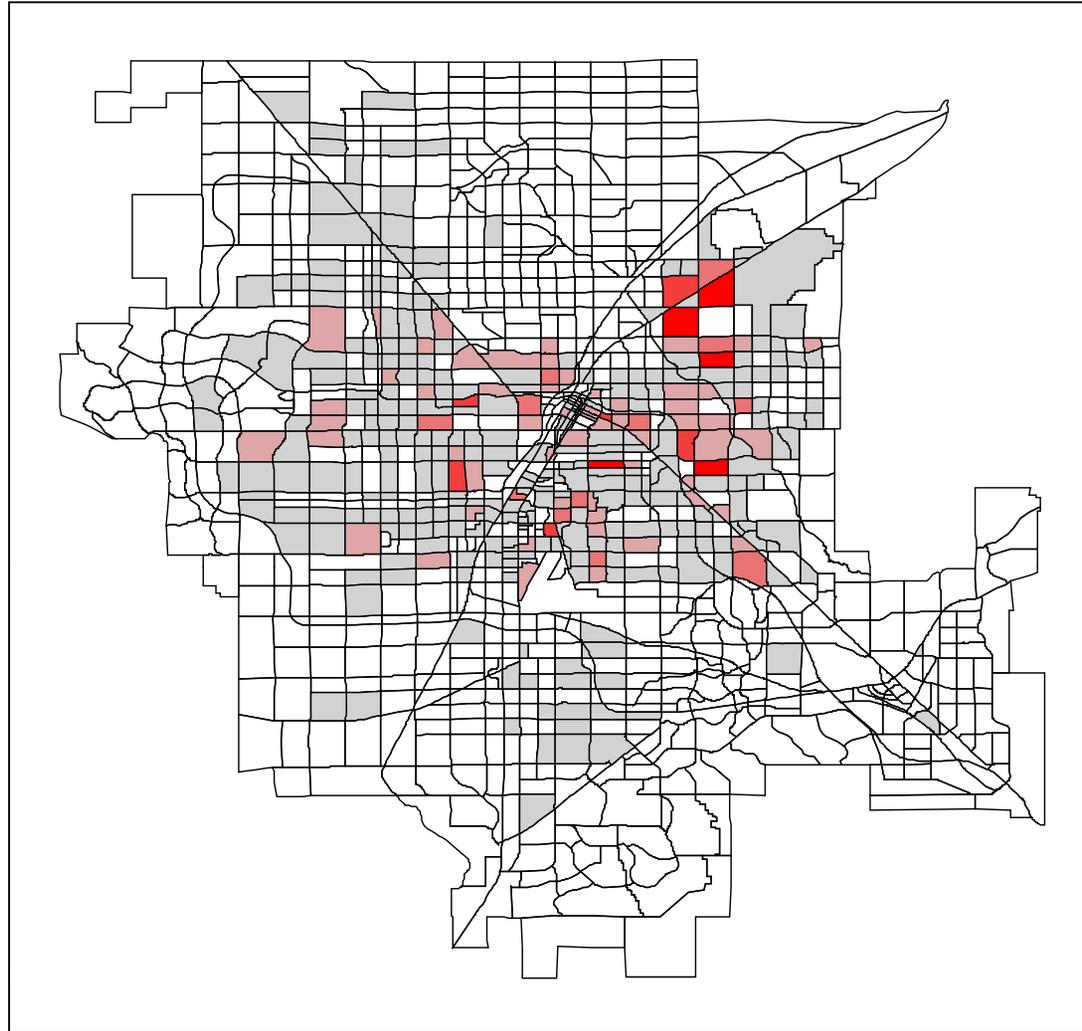


Figure 32.7:

## Relative Distribution of Predicted Crime Trip Origins

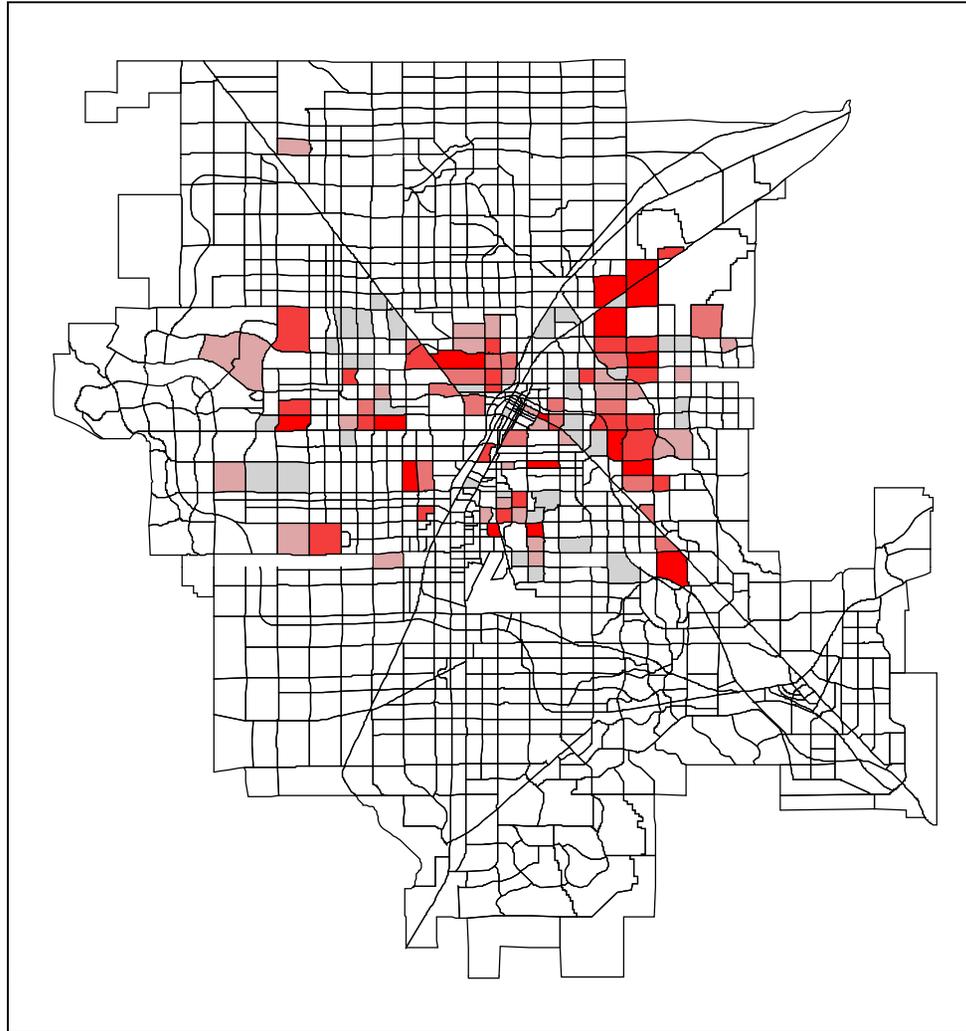
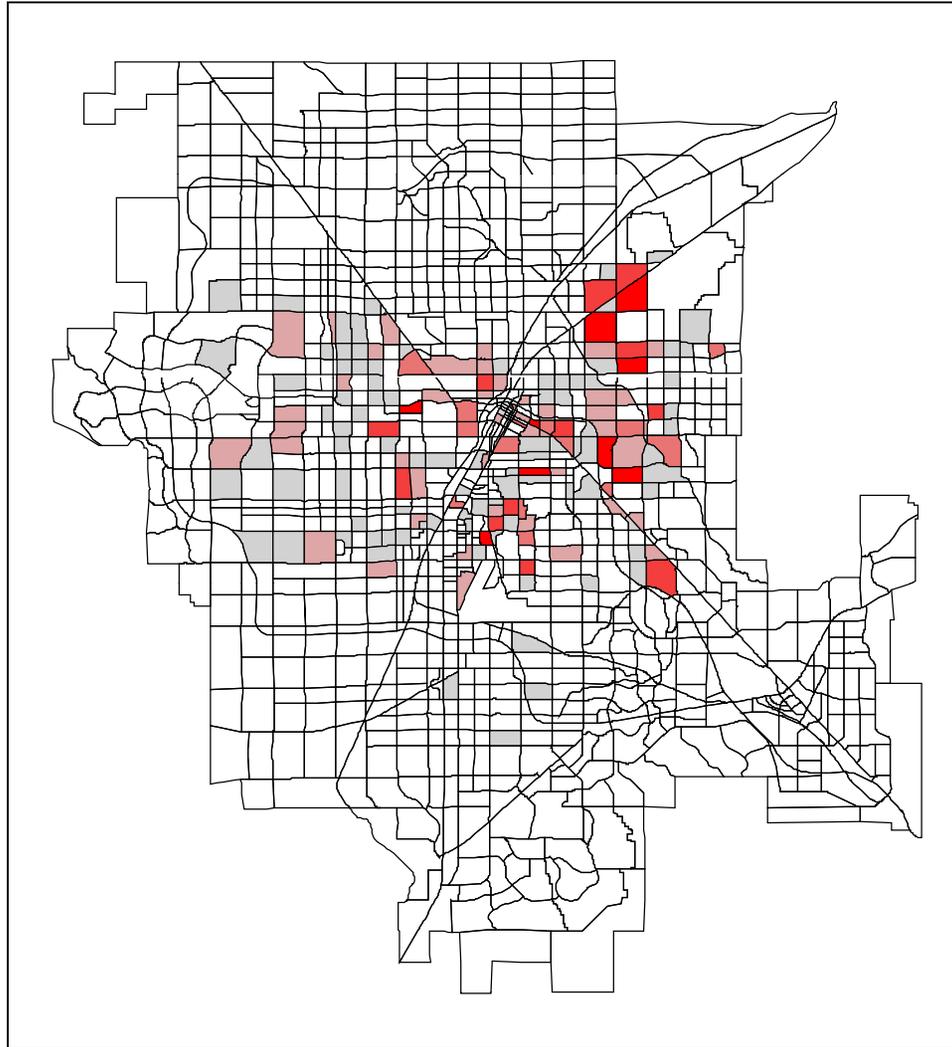


Figure 32.8:

# Relative Distribution of Predicted Crime Trip Destinations



Longitudinal forecasting of crime trip frequency by data from one year to the next year performed very poorly; this is probably an artifact of the still-unexplained drastic variation in frequency between the three years considered in this study. Results from other years may exemplify very different findings.

Side-by-side comparisons of observed and predicted crime trip origins reveal some persuasive similarities, but significant discrepancies, also (Figure 32.9 and Figure 32.10). In general, relative proportions are very accurately described, but smaller producing zones are somewhat underestimated (the model seems to perform better on zones with higher productions).

A side-by-side comparison of observed and predicted crime trip destinations suggests that, proportionally, the model again performs very well, particularly on zones with higher production scores. Zones with very weak crime trip destination productions (of one or two crimes) are not as accurately depicted.

## **Trip Distribution**

Assignment of trip links between TAZ polygons performed very well (Figure 32.11). Originally, some concern was felt that the assignment of crime events to TAZ centroids (rather than using the actual crime scene and home address coordinates) might result in significant distortion; however, this does not appear to have occurred. Compare the raw (actual) crime trip lines with the centroid-corrected trip lines to see how neatly they match (Figure 32.12). The resulting distance decay and impedance functions perform perfectly well. There are almost no discrepancies visible to the naked eye.

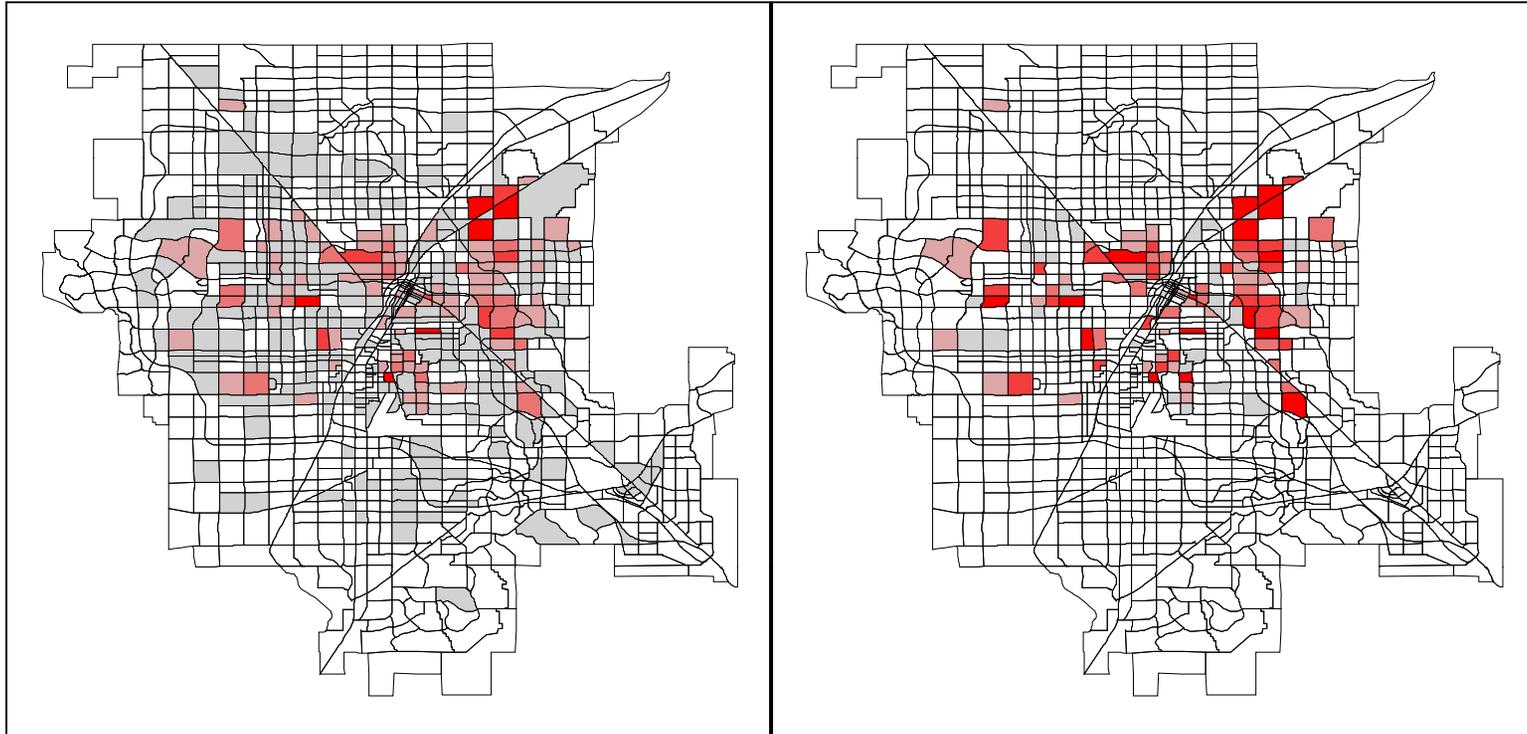
Various impedance function calculations were attempted in the course of this study. Eventually, an adaptive (100-bin) normal interpolation with 100 minimum samples was selected as the best fit. However, a negative exponential impedance function also fit well, similar to the Baltimore County and Chicago models.

Intra-zonal crime trips - those having both origin and destination within the same TAZ, cannot be displayed as lines since they have no length. Instead, they can be represented by points (Figure 32.13). Inter-zonal crime trips, on the other hand, are better displayed by lines (Figure 32.14).

Overall, intra-zonal crime trips accounted for 42% of all crime trips but only 12% of robberies, indicating a much longer "hunting range" for robbers; this may be in keeping with the hypothesis that the tourist corridors draw robbery crime trips as destinations which originate in other neighborhoods. More than 50% of sexual assaults were intra-zonal, indicating a

Figure 32.9:

# Comparison of Observed and Predicted Crime Trip Origins



**Observed**

**Predicted**

Figure 32.10:

# Comparison of Observed and Predicted Crime Trip Destinations

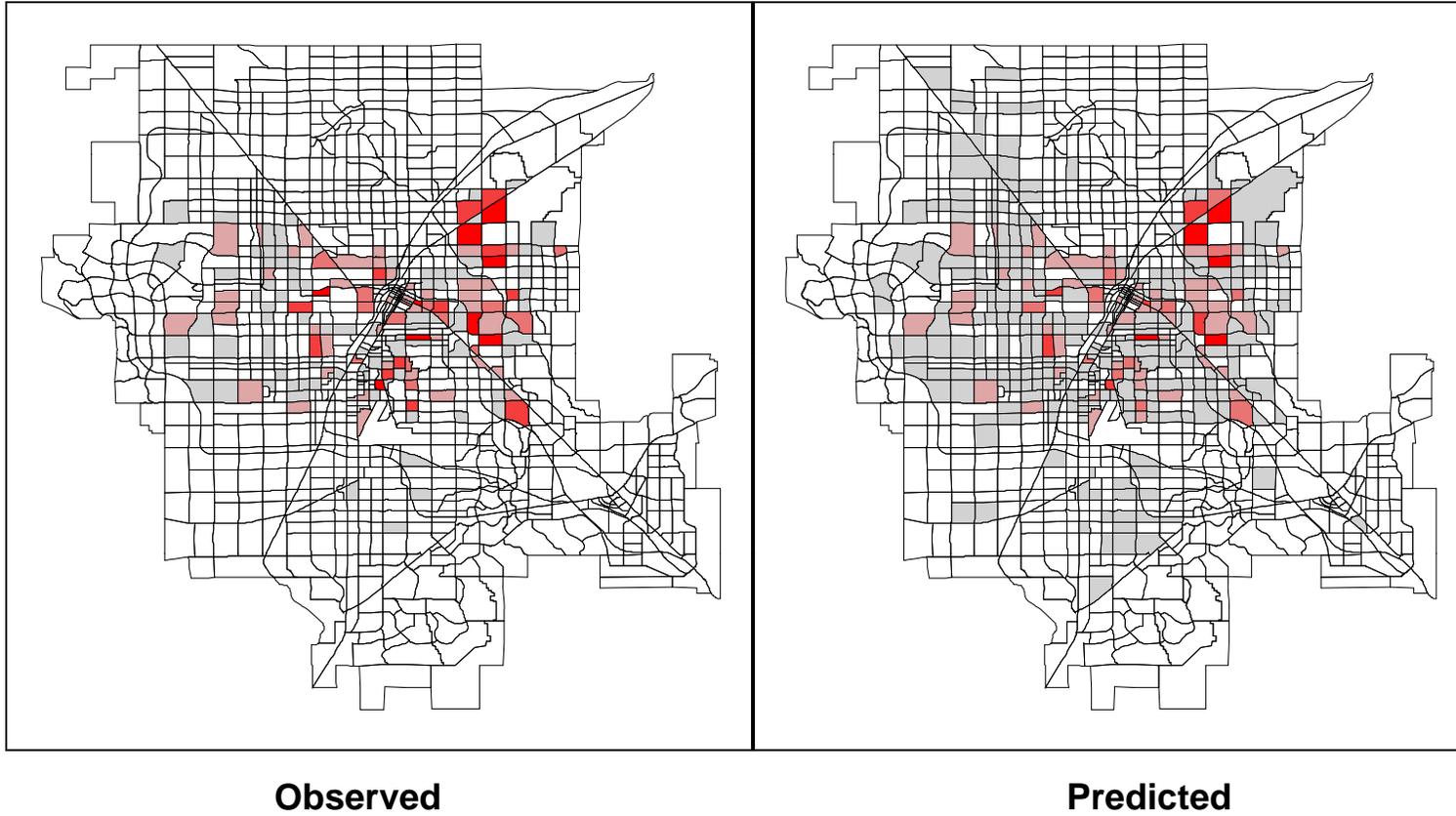


Figure 32.11:

# Observed Crime Trips

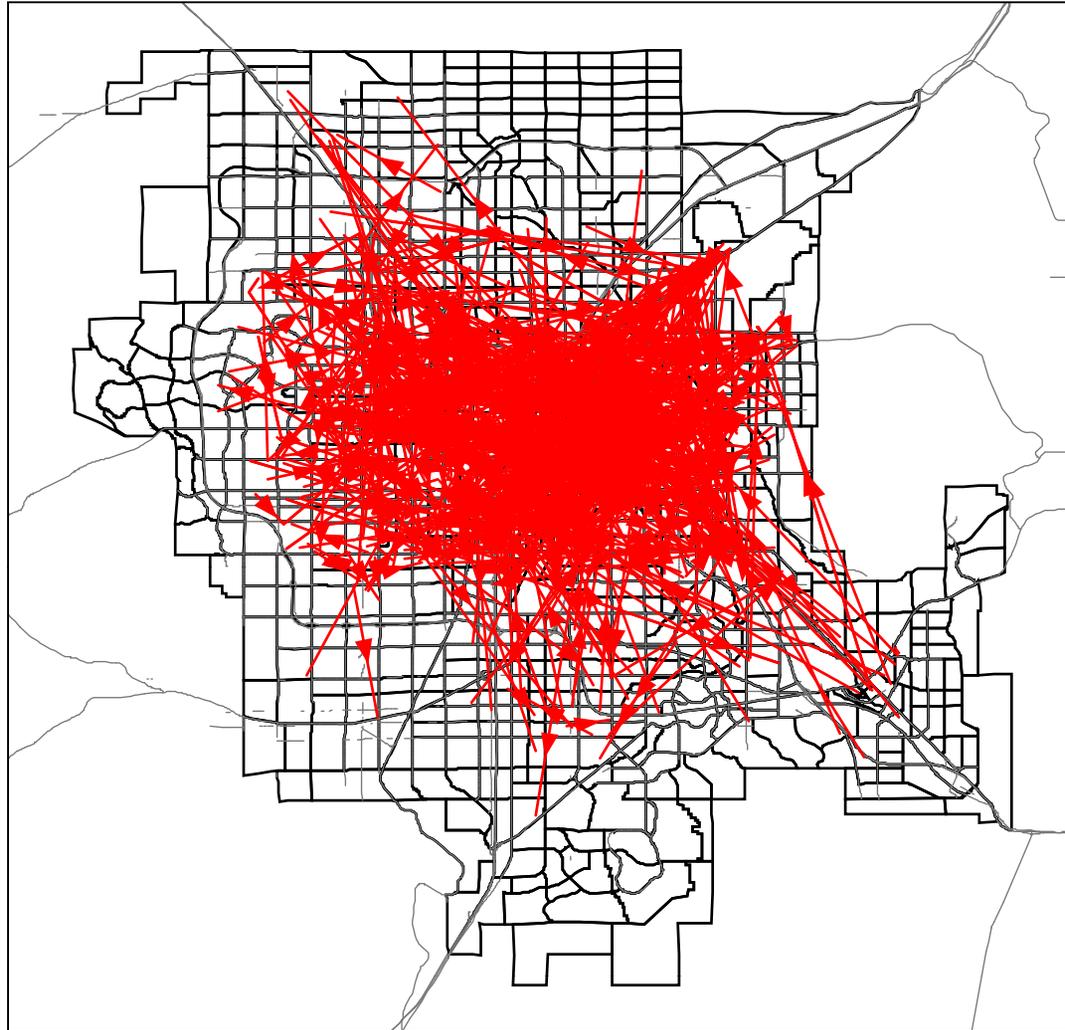


Figure 32.12:

# Comparison of Observed and Predicted Crime Trip Links



**Observed**

**Predicted**

Figure 32.13:

## Predicted Intra-zonal Crime Trips

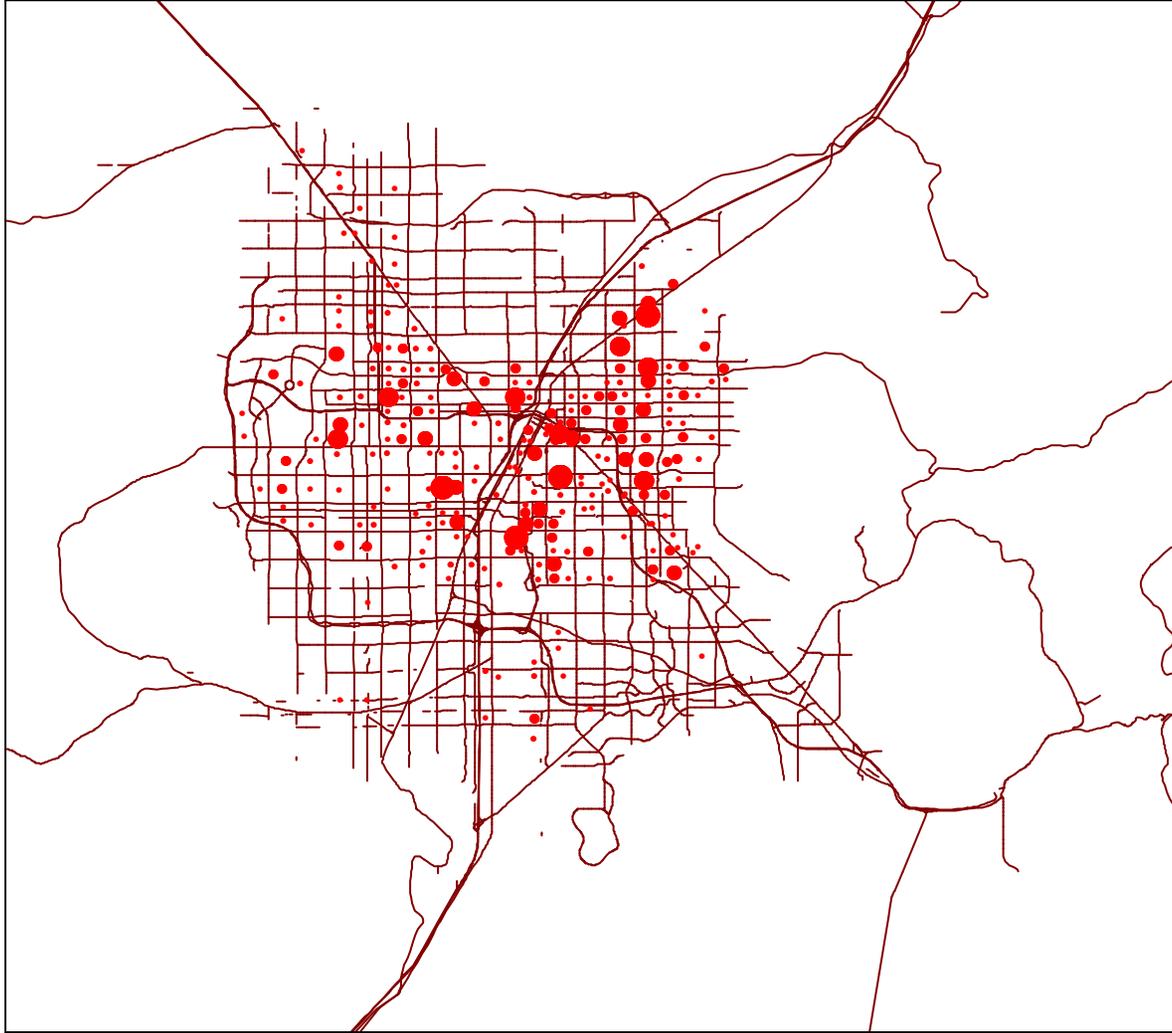


Figure 32.14:

# Top 100 Predicted Inter-zonal Crime Trips Allocated to All Streets



shorter-than-usual hunting range for sexual attackers, who seem to prefer striking in their home neighborhoods.

## **Mode Split**

Unfortunately, the mode split portion of the travel demand model is the weakest element for the Las Vegas data. Transportation modes across metropolitan Las Vegas are varied. Typical of a western city, the overwhelming majority of residents rely on private automobiles for transportation as do many tourist visitors. However, this mainstay is supplemented by a robust bus system as well as alternate personal transportation for short trips (i.e., walking, bicycling, or scooters). The picture of automobile transportation is somewhat muddled by the higher than usual dependency on taxi-cabs and limousines for transportation by out-of-state visitors.

Data provided by the LVMPD included a field called "Method of Departure" which was intended to contain information about how the offender departed the scene of the crime which, in turn, would have been an effective way of calculating probable mode split for crime trips sampled. Unfortunately, this data field was blank in the overwhelming majority of cases (approximately 4% contained entries, and only 75% of these - 3% overall - contained apparently valid data).

Therefore, any empirical estimation of mode split for these data requires inference from other data. For example, auto theft crimes may safely be assumed to use a car to provide transportation for at least some portion of the crime trip. In other cases, the plain-text narrative includes vehicle descriptions or statements about how the offender moved that were not distilled into the correct field. Unfortunately, the large volume of cases makes recovering information from these free narratives impractical for the small number of cases in which mode split information can beneficially be derived.

Due to this lack of reliable data, only two mode split options were included in this analysis: Walking and Driving. Default impedance functions proved very acceptable for both modes: Inverse Exponential for walking trips and Lognormal for driving.

## **Network Assignment**

The complete street centerline (SCL) file for the metropolitan Las Vegas area was available in a routable format (topologically rectified ESRI Shapefile); however, this file proved prohibitively large and unwieldy for the A\* shortest-path/least-cost algorithm implemented in *CrimeStat*. Instead of the complete SCL data layer, a layer consisting only of arterial streets and freeways was used instead. This major roads file proved adequate to neatly explaining the

probable transportation path choices made by the top 100 and top 300 inter-zonal crime trips (Figures 32.15 and 32.16).

In general, the visual goodness-of-fit for predicted crime trips improved as the category of crime was narrowed. Predictions from one year to the next remained weak, probably as a result of the as-yet-unexplained radical variance in crime frequencies across all study categories. However, within discrete crime categories predictive capabilities were sometimes visually impressive.

## **Modeling Different Crime Types**

### **Auto Theft Site to Recovery Site**

In the case of auto thefts, an attempt was made to isolate the movement from vehicle theft site to vehicle recovery site rather than use the theft site and offender home location as the destination and origin, respectively, of the crime trip. It was hoped that this variation of the travel demand model for crime trip analysis might prove more useful for this type of data than home-based crime trips partly because more accurate location information was available for recovery sites than for home locations. Also, it was hypothesized that the theft/recovery "trip" segment might prove more representative than the home/theft trip.

Results for auto thefts appeared weak with predicted crime trips much longer than the observed (Figure 32.17). While the observed trips focused tightly on the central core areas and densely-populated residential zones, the predicted trips seemed to skirt the edges of the metropolitan area. This is possibly due to an implied overemphasis on freeway travel which may be correctible with better network allocation parameters. The median distance for observed crime trips was 2.3 miles.

### **Residential Burglaries**

Differentiation of residential from commercial or auto burglaries was accomplished by three filtering criteria: Statute, Premise, and Zoning. Some specific Nevada Revised Statutes have been reserved for residential burglaries; burglaries in which these statutes were cited were therefore accepted as residential in nature. Categorical Premise type data was provided in the MO data for each crime; when this data explicitly noted a residential site, these cases were also accepted as residential.

Some burglaries did not specifically include a residential statute or explicitly residential premise code; but were spatially located in areas of the jurisdiction reserved for residential rather

Figure 32.15:

# Top 100 Predicted Inter-zonal Crime Trips Allocated to Freeways and Major Streets



Figure 32.16:

# Top 300 Predicted Inter- and Intra-zonal Crime Trips Allocated to Freeways and Major Streets

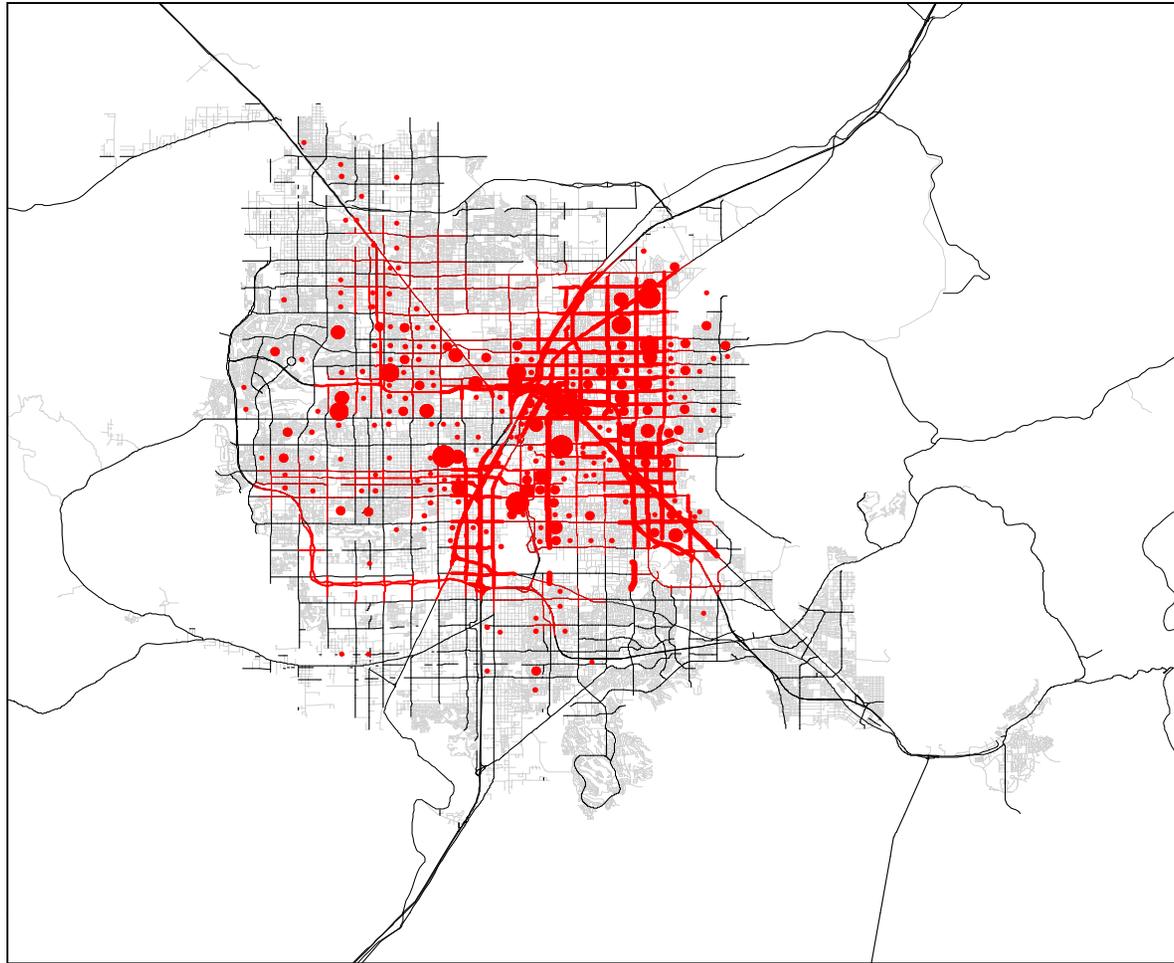
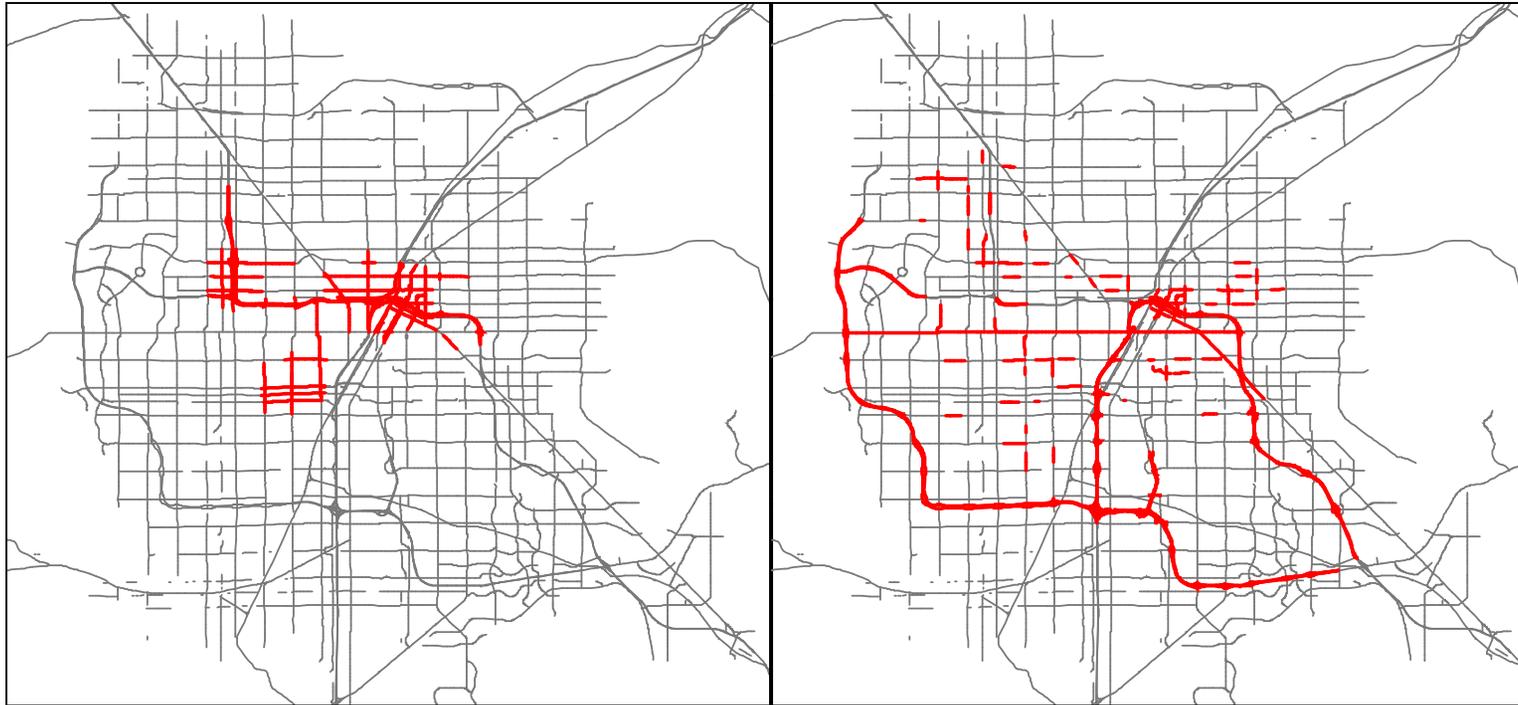


Figure 32.17:

# Top 100 Observed & Predicted Auto Theft Crime Trips Allocated to Freeways and Major Streets



Observed

Predicted

than commercial, industrial, or other zoning purposes. These cases were therefore also accepted as residential in character.

Results for analysis of residential burglaries was more promising than for auto thefts, or for burglaries overall (Figure 32.18). While, again, observed crime trips focused on the most densely-populated residential neighborhoods and predicted crime trips were much longer and spread more far afield, this spread was much smaller than that seen in auto thefts and more closely conformed to the observed distribution. The median distance for residential burglary crime trips was 1.1 miles.

### **Sexual Assaults**

The spatial distribution of sexual assault crime trips in many ways seemed to invert the problems seen in the predicted crime trips for auto thefts and residential burglaries. In the previous examples, an observed tendency toward centrality seemed to be confused with a predicted tendency toward dispersion toward outlying areas. In this case, however, a very nebulous, outlying distribution of observed crime trips (centering in three faint clusters around the perimeter of the central metropolitan region) was observed. The predicted crime trip distribution mistakenly emphasized central areas, and seemed to completely fail to predict the southeastern-most "cluster" of crime trips (Figure 32.19).

The large median crime trip length for sexual assaults - 3.2 miles, may help explain the relatively poor predictions of these results. Different impedance functions will probably help improve the reliability of this model against these types of crimes.

### **Robberies**

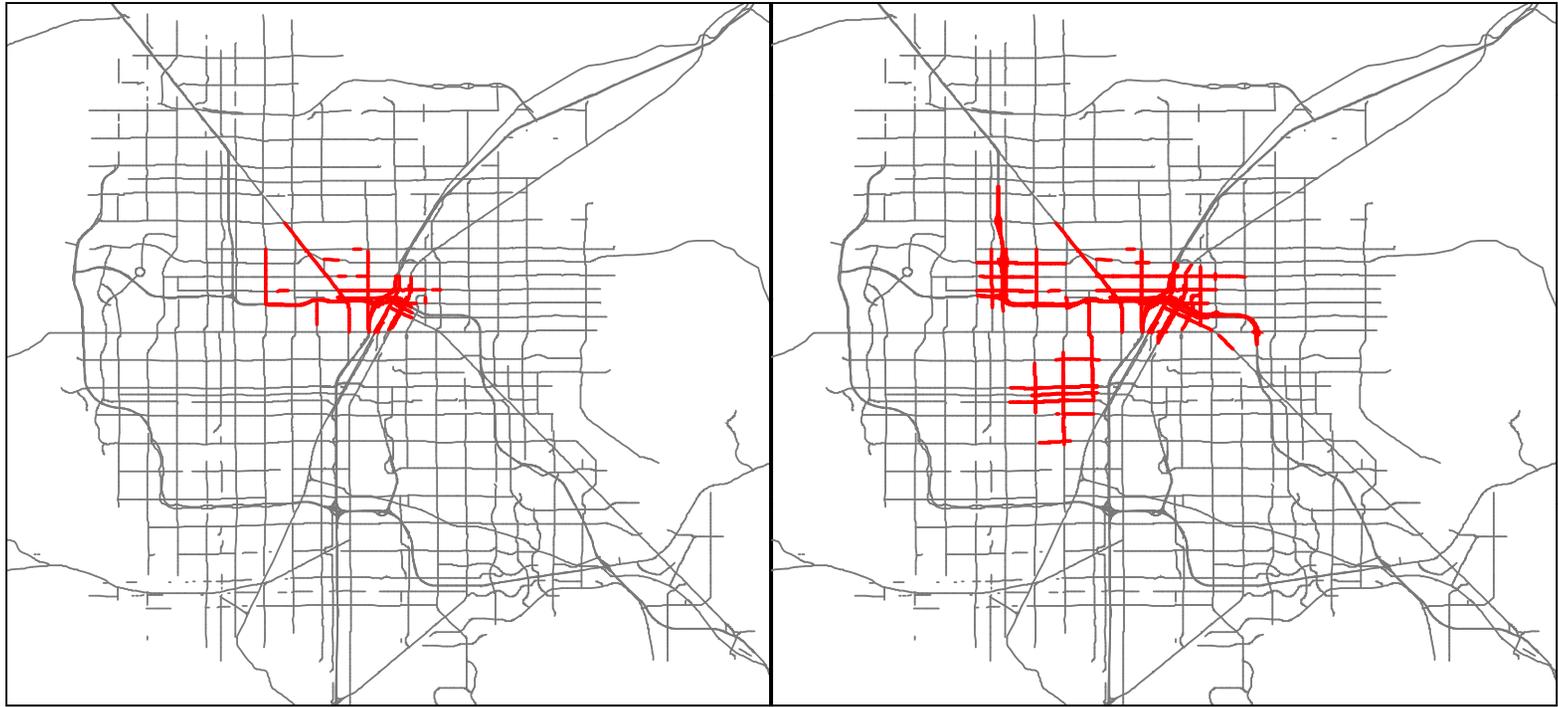
Robbery crime trips in Las Vegas appear to closely parallel the major gaming and transportation corridors running north to south through the center of the metropolitan area (Figure 32.20). The visual fit of predicted against observed crime trips was most impressive against these cases. Although the predicted crime trip distribution appears more compact and centralized than the observed, the directionality and polarity of the two parallel nicely, and make a striking visual match. The median crime trip distance for robberies was 2.3 miles.

## **Conclusions**

Overall, the model appeared to perform well for some crime types but weaker for others. One of the most troubling problems facing the evaluation of the network assignment stage of the model is the lack of any good final metric other than visual approximation for determining the

Figure 32.18:

# Top 100 Observed & Predicted Residential Burglary Crime Trips Allocated to Freeways and Major Streets

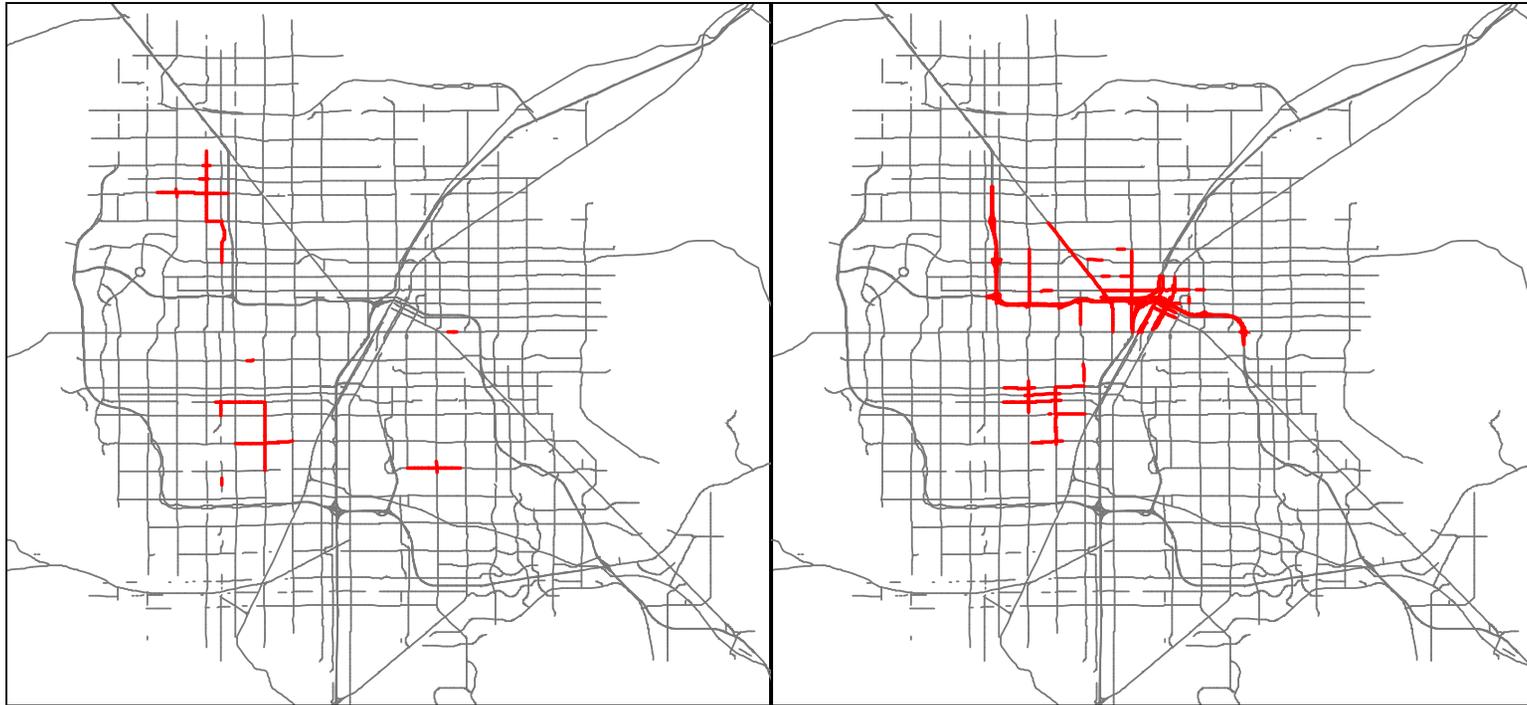


Observed

Predicted

Figure 32.19:

# Top 100 Observed & Predicted Sexual Assault Crime Trips Allocated to Freeways and Major Streets



Observed

Predicted

Figure 32.20:

# Top 100 Observed & Predicted Robbery Crime Trips Allocated to Freeways and Major Streets



Observed

Predicted

value of the resulting prediction. Some measurement of congruence is needed to make the determination of usefulness reliable and valid.

The first stage of the model - crime trip generation, is arguably the most useful to law enforcement. This elegantly simple model can readily be adapted to different types of data, and with the inclusion of additional regression methods (specifically the negative binomial distribution model) to supplement the existing ordinary least squares (OLS) and Poisson variants, this feature is likely to remain useful for the foreseeable future.<sup>2</sup>

The second stage of the model - crime trip distribution, is also potentially highly useful. The analysis not merely of where offenders live or where crimes are committed but of the travel and transportation decisions linking the two locations, may have significant repercussions for crime analysts. This type of analysis will be particularly useful for strategic and administrative analysts when recommending manpower allocation, beat boundaries and precinct/district configuration schemes, and assessing the impact of major developments such as transportation corridors, shopping malls, or sports complexes on the distribution of crime.

The mode split stage of the model was difficult to apply meaningfully to the Las Vegas data in this study because of deficiencies in the data itself. Either transportation choice values were not recorded, or were recorded in irretrievable formats, making an empirical evaluation of offenders' transportation choice proclivities impractical. Failing the availability of empirical data, falling back on overall trends in public transportation choice are all that is possible for the analyst. Since it is possible that crime trips may be qualitatively different than other types of trips on which these statistical models have been based, further research is required to assess whether or not these standards will be applicable to criminal behavior.

The final stage of the model - network assignment, functioned mechanically as expected, but did result in some potentially weak results (such as overemphasis on the speed of freeways apparent in some results) which may be overcome with better mode split and network choice parameters.

One aspect of the model that caused for initial concern, the aggregation of crimes to the Traffic Analysis Zone polygon level, proved to have no significant impact on the resulting analysis. The TAZ structure seems admirably suited to analysis of this sort of movement - as indeed one might expect from its provenance.

The most successful predictive variables for estimating crime trip production, whether of origins or destinations, were infallibly total population, total employment, and income. Inclusion

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<sup>2</sup> This has been implemented since this chapter was initially written.

of additional variables distorted rather than improved the predictive value of the model, most of the time with measurable multicollinearity which was not always apparent a priori.

With the mechanical aspects of the model - as implemented in the latest version of *CrimeStat*, complete and functioning correctly, it remains to be learned how to better calibrate and implement the model to make it an effective tool for law enforcement analysis and planning.

## References

State of Nevada (2012). Laws of the State of Nevada. Nevada Law Library: Reno.  
<http://www.leg.state.nv.us/law1.cfm>.