AN APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS (GIS): THE UTILITY OF VICTIM ACTIVITY SPACES IN THE GEOGRAPHIC PROFILING OF SERIAL KILLERS

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Arts

in

The Department of Geography and Anthropology

by
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B.A., University of Tennessee, 1999
August 2004

ACKNOWLEDGMENTS

The author wishes to thank the twelve residents of East Baton Rouge Parish who graciously supplied the day-to-day activity data necessary for the successful completion of this study. Additional thanks are paid to Ms. Mary H. Manhein my advisor, and to the other members of my thesis committee, Dr. Andrew Curtis, Dr. Michael Leitner, and Dr. Rebecca Saunders. Their support helped make this thesis possible. Special thanks are also paid to Mary, who afforded me the opportunity to work in the FACES Lab, enriching my graduate experience immeasurably. The author would like to thank Dr. Helen Regis for her help in the development of the survey. Thanks to Lt. Karl Kretser for the enthusiastic support and advice. The author would also like to thank Ms. Sarah Hinmann and Ms. Jackie Mills for patiently answering all of my ArcView® questions. Finally, the author thanks his wonderful wife and family for their unquestionable support, encouragement, enthusiasm, and tolerance.

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ABSTRACT

Today, computer technology is producing new methods of investigation into the complex nature of serial killers; among these are geographic profiles. Yet, due to the lack of proven success, budgetary constraints, and the inherent multifaceted nature of serial murder, these geographic profiles have not been completely embraced by the law enforcement community. Because of this, the academic and law enforcement communities continue to refine and develop new methods to solve serial killer cases.

This thesis investigates the possibility of identifying the location of the interaction site of a serial killer and his victims using a commercial geographic information system (GIS) as the primary tool. This will be accomplished by analyzing the daily activities of three hypothetical victims of serial murder. A comparison of survey results from the hypothetical victims of this study and their associates shows evidence that victim activity areas can contribute to serial killer investigations. This new method demonstrates that, instead of costly spatial analysis software used today in geographic profiling, geographic information pertinent to a serial killer investigation can be disclosed using a commercial GIS. The addition of a geographic method that adds the component of time and focuses on the daily routine of the victim will complement existing profile methods and provide investigators with a new tool in understanding serial killer phenomena. A law enforcement perspective of this method and GIS is also presented.

CHAPTER 1: INTRODUCTION

The complex nature of serial killers has led to the development of various investigative methods in order to apprehend the assailants. Among others, criminologists, forensic scientists, psychologists, anthropologists, and geographers continue to develop new techniques and refine existing methods in the pursuit of understanding and capturing serial killers. One of the more topical techniques among these methods are geographic profiling systems.

Geographic profiling systems are usually implemented as computer-based applications. Spatial relationships between points relevant to a murder are analyzed through specifically designed software packages or through the use of geographic information systems (GIS). Geographic profiling systems use information from a serial offence in order to estimate the offender's residence (Canter & Gregory, 1994; Godwin, 2003a; Rossmo, 2000). The ability to create new analytical methods of temporal and spatial data has led to the creation of different types of software applications in serial killer investigations. While there are various software programs available to create geographic profiles of serial killers, all of the current programs' primary focus is the identification of the serial offender's residence. Some of these software packages are expensive and require specialized training to operate the systems (Godwin, 2003b; Rossmo, 2003).

This thesis investigates the possibility of identifying the location of the interaction site of a serial killer and his victims using a commercial GIS as the primary tool. This will be accomplished by analyzing the daily activities of three hypothetical victims of serial murder. Friends, family members, and coworkers will recreate the day-to-day activities of three hypothetical victims by answering questions about the victim's daily routine. With the use of GIS, routes and locations common to the multiple victims will be identified. These shared locations could be potential killer-victim interaction sites.

Rather than identifying static locations and routes within the hypothetical victims' lives, the element of time will be added. Not only will routes and locations be identified, but also time associated at each place will be recorded. The use of time makes this approach multidimensional, which more accurately recreates the victim's day-to-day routine (Hagerstrand, 1970). Realism created by the use of time will make this method a viable resource for law enforcement. The method investigated in this thesis will potentially enable law enforcement to identify the location or locations of killer-victim interaction in order to focus their investigation on precise sites during specific times of the day in their search for a serial killer.

CHAPTER 2: LITERATURE REVIEW

Investigators have long understood that geography is a valuable tool in criminal analysis. Crime mapping using pins and static maps is quickly being replaced by more advanced systems of analysis. One such system is a geographic information system (GIS). Not until the 1990s were desktop computers powerful enough to manipulate efficiently complex software programs like geographic information systems. At that time, the full potential of geographic analysis of crime was realized (Harries, 1999). The use of GIS has allowed the investigator to manage and synthesize large quantities of data, displaying the data visually in map form.

Software applications have been developed for GIS in order to aid law enforcement in the apprehension of serial murderers. Existing geographic profiling systems primarily focus on the encounter, attack, murder, and dump sites (Rossmo, 2000). These elements of the crime are used to predict the offender's residence. While these elements are of primary importance to the crime itself, they neglect the victim's activity area. Rather, police and researchers have focused their attention on the offender and, specifically, his or her residence.

Numerous geographic profiling systems have been developed in order to aid law enforcement in the apprehension of serial criminals. These programs have been used successfully to predict the area of a killer's anchor point, usually his residence (Newton & Swoope, 1987; Rossmo, 2000). Geographic profiling systems have also been met with criticism in their ability to effectively contribute to the apprehension of serial murderers (Gore &Tofiluk, 2002; Snook, 2000; Snook et al., 2002).

Former police detective Dr. Kim Rossmo developed Rigel, a geographic profiling system. Rossmo also developed the concept of Criminal Geographic Targeting (CGT). Criminal Geographic Targeting is based on an algorithm that takes into account distance decay functions, Manhattan distances, and the relationship between crime locations and offender residence (Rossmo, 2000). The Rigel system produces the likely residence of an offender based on information provided in a serial murder, the encounter, attack, murder, and dump sites. Rossmo's geographic profiling program is grounded in the least effort principle. The least effort principle states that people carry out their routine activities in the closest possible locations (Zipf, 1950). An activity space contains those areas that comprise a person's habitual geography, made up of routinely (daily or weekly) visited places and their connecting routes (Jakle et al., 1976). Within the activity space are anchor points or bases, the most important places in one's spatial life (Courcelis et al., 1987). The Rigel system uses location information provided by a series of crimes to interpret the offender's mental map and calculate the most probable area of his anchor point, which is usually his residence (Rossmo, 2000).

Rigel is arguably the most popular system used today, utilized throughout Canada and Britain, as well as by the United States Bureau of Alcohol, Tobacco, and Firearms. Rossmo's system is very expensive and requires extensive instruction in the use and interpretation of the product (Rossmo, 2003). This makes the system unobtainable by law enforcement groups with minimal budgets and allowances for training.

Another popular crime analysis program is CrimeStat2®. Ned Levine developed CrimeStat2® through research grants from the National Institute of Justice. CrimeStat2® includes spatial statistical routines that can display the overall distribution of crime incidents in multiple ways. Regional correlation of crime, hot spot identification, journey to crime analysis, and correlated walk analysis are all achievable using this system. CrimeStat2® is able to calculate multiple spatial statistics and display the results in map form using various GIS platforms.

Dragnet is another geographic profiling program. David Canter of the University of Liverpool, England, developed Dragnet. Unlike other geographic profiling programs that predict the location of an offender's residence, Dragnet prioritizes geographic locations based on the likelihood that the offender's residence is located in a given area. Canter's studies have identified characteristics of serial offenders based on the way in which the offender commits a crime (1993, 1994, 2000).

Maurice Godwin developed the Predator© geographical profiling system. The Predator© system also identifies the serial offender's home base using known sites of serial criminal activity. Godwin's model is based on his research that a serial killer's spatial behavior tends to be wedge-shaped (Godwin, 1998). Predator© projects the trips an offender makes to the crime site and reverses the directional model to predict the location of an offender's residence (Godwin, 2001). Godwin believes that other geographic profiling systems could be more efficient if these systems considered the directionality of crimes (Godwin, 2001).

Geographic profiling systems are based on tenets of environmental criminology and crime pattern theory. According to Brantingham and Brantingham, four dimensions of crime, "a law, an offender, a target, and a place" must intersect in time for a criminal act to occur (Brantingham and Brantingham 1981, p.7). Environmental criminology is the study of the place that crime occurs. Proposed by Brantingham and Brantingham (1981, 1984), crime pattern theory posits that criminal acts are most likely to occur in areas where the awareness space of the offender intersects with a target victim. Re-creation of the day-to-day activities of a victim of serial murder also aids in defining a killer's 'mental map', a term coined by Peter R. Gould in 1974. A mental map is defined as:

> "a representation of the spatial form of the phenomenal environment which an individual carries in his or her mind. The representation is of the individual's subjective image of place (not a conventional map) and not only includes knowledge of features and spatial relationships but also reflects the individual's preferences for and attitudes towards places…The product of this process, at any point in time, is a mental or cognitive map and can be shown cartographically as a perception surface." (Goodall, 1987, p.299)

Crime pattern theory is a combination of theories that attempt to explain criminal activity based on a criminal's decision-making processes. One such theory is routine activity theory. Routine activity theory examines offender-victim interaction by investigating how regular activities can lead to illegal activities (Cohen and Felson, 1979). For illegal activities to occur, three essentials must be in place: 1) motivated offenders, 2) suitable targets, and 3) the absence of guardians. Felson (1998) also expanded this theory to include the amount of people present in an environment at a certain time. Felson proposed that the natural rhythm of a location reflected the times of day when a location would be populated. Felson's research also implies that a killer will seek out locations that are populated enough to contain suitable targets, yet will not pose a threat to successful victim selection. The tenets of rational choice theory are also reflected in crime pattern theory. Rational choice theory states that criminals will choose to commit a crime only if it benefits them in some way (Cornish and Clarke, 1986).

As a tool for investigation, geography allows criminal investigators to examine crime in relation to its surrounding environment. By incorporating time into a geographical analysis, the ability to observe how a situation changes over time becomes realized. The addition of a time component can help to understand what seem to be random spatial patterns on maps. The element of time may also provide value to particular locations in that a location in which more time is spent could present a more likely interaction site.

Torsten Hagerstrand introduced the concept of unified space and time in geography. By adding time to space, space becomes four dimensional rather than three dimensional. This four-dimensional approach to geography more accurately represents individual activities of people in time and space, with time often influencing human affairs more than space (Hagerstrand 1970, 1973, 1978). Unified time-space recording allows the observer to isolate events and look for patterns. After these patterns are established, statistical analysis is used to confirm or deny relationships between events (Hagerstrand, 1973).

It is also necessary to explore the association between the individual situation and aggregate information (Hagerstrand, 1970). Aggregate information does not reflect micro environmental factors that the individual encounters and to which he adapts. In order to understand how an individual operates within an environment, time is essential. The addition of time, along routes and at locations, limits other possible locations that can be exploited (Hagerstrand, 1970).

The ability to accurately trace paths of individuals through the landscape becomes possible with the addition of time. Life requires association with various elements of one's surroundings (Hagerstrand, 1978). Hagerstrand classifies these elements as:

1. other individuals
2. indivisible objects (such as other living organisms, machines, tools)
3. divisible materials (such as air, water, minerals, foodstuff)
4. domains

A domain is an informal location such as a home, real-estate unit, or a formal location such as a state. Domain refers to a geographic unit of "position" in space, which is not always fixed in location (Hagerstrand, 1978). In a regional setting there are a limited amount of domains that individuals may utilize. Because of this, individuals and their associated paths will often share domains.

A geographic profiling system that records and identifies a serial killer's multiple victims' day-to-day routine has the potential to identify the killer-victim interaction site. The utility of analyzing the victim's geographic profile, rather than the killer's, has been referred to in literature, but is yet to be investigated (Clarke et al., 1993; Ford, 1990; Rossmo, 2000). Maurice Godwin, developer of the Predator© geographic profiling system, believes that victim target networks can help police identify previously unknown and possible future victims (1998). Victim social networks also help define areas where one may fall prey to a serial murderer. The choice of victims may also provide insight into the nature of the killer (Douglas et al., 1986).

The technological capabilities of today are producing new methods of investigation into the complex nature of serial killers. Yet, due to the lack of proven success, budgetary constraints, and the inherent multifaceted nature of serial murder, these geographic profiles have not been completely embraced by the law enforcement community. Because of this, the academic and law enforcement communities continue to refine and develop new methods to solve serial killer cases. The addition of a geographic method that adds the component of time and focuses on the daily routine of the victim will complement existing profile methods and provide investigators with a new tool in understanding serial killer phenomena.

CHAPTER 3: METHODS AND MATERIALS

Existing geographic profiling systems primarily focus on the encounter, attack, murder, and dump sites of murders (Rossmo, 2000). While these elements are of primary importance to the crime itself, they neglect the victim's activity area. Rather, police and researchers have focused their attention on the offender, and specifically, his or her residence. By focusing on the activity areas of a serial offender's victims, criminal investigators would be able to focus limited time and resources to an area of likely offender-victim interaction.

Serial murder involves three or more victims (Ressler et al.,1988). In order to simulate a serial murderer operating in the area of Baton Rouge, Louisiana, three hypothetical victims were selected for interviews. These hypothetical victims were previously unknown to the author. The three hypothetical victims were all males aged 20-23 years. The three hypothetical victims were the primary informants for the study.

The series of interviews with the primary informants were done in person and were recorded using an Olympus® micro cassette recorder. In the first phase of interviews, the primary informants spent approximately one hour answering survey questions (Appendix A) about their day-to-day activities and the routes that were used to get to the activity space. The survey questionnaire was created in consultation with a book on survey methodology (Salant & Dillman, 1994) and personal communication with anthropology and geography professors (Regis, 2003; Curtis, 2003). The primary informants provided specific day, time, and frequency spent at each activity space and route. In the second phase of interviews, associates of the primary informant answered questions regarding the primary informant's day-to-day activity areas and routes to these activity areas. The associates represented one of the following: parent, friend or coworker. Additionally, the associates provided specific day, time and frequency spent at each activity area and route. These questions were identical to the questions posed to the primary informants (Appendix A). The second series of interviews were conducted over the telephone.

All data obtained from the interview process were imported into ArcView® v.3.3 GIS software. Data were segregated by individual response to the survey questions. Route information to and from each activity was recreated by using the 'Geoprocessing' extension of the ArcView® software. The 'Model Builder' extension of the ArcView® software was applied to route and location shapefiles. This extension allowed the route and location shapefiles to be combined. The 'Model Builder' extension also allowed distance buffers to be placed around each location.

Attribute information for each route and location was categorized in a way that allows for multiple combinations of information to be displayed. An abbreviated sample location attribute table is located below (Table 3.1).

Table 3.1 Sample Location Attributes

Address	Location	Trips	Duration	Loctype	Monday	Sunday	Ltime	LID
3425 State Road	Jack's Bar	24.000	3.00	L	Y	N	MNE	CS1
102 Jefferson Ave.	Sorority House	20.000	1.50	F	N	Y	LE	CS2

The following table defines location attribute categories used in the GIS.

Table 3.2 Location Attribute Categories

Attribute	Definition
ADDRESS	the physical address of the location
LOCATION	the actual name of the corresponding physical address
TRIPS	the number of trips made per month by the hypothetical victim
DURATION	time in hours per month
LOCTYPE	Type of location. Categories for 'LOCTYPE' are: 'D', 'F', 'L', 'H', 'S', 'W', and 'WL'; see text
Days of the Week	'Y' or 'N'; 'Yes' or 'No', denotes if the hypothetical victim traveled or possibly traveled to the corresponding location on a given day.
LTIME	denotes the approximate time of day that the hypothetical victim visited each location
LID	Arbitrary identification indicator

Location information of each activity was matched to the corresponding East and West Baton Rouge road map file location using the 'Geocode Addresses' extension of the ArcView® software. In the GIS tables, each day of the week was represented. Categories for 'LOCTYPE' are: 'D', 'F', 'L', 'H', 'S', 'W', and 'WL'. 'D' symbolizes day-to-day. A day-to-day location is a location that fulfills necessities of day-to-day life such as the grocery, bank, or laundry. 'F' symbolizes family or friends. These are the home locations of family and friends. 'L' symbolizes leisure. Leisure locations represent sites at which free time is spent. 'H' symbolizes the home of the hypothetical victim. 'S' represents school. 'W' denotes work and 'WL' indicates a work lunch location.

The following table demonstrates the nomenclature used in 'LTIME' and the corresponding time frame. 'LTIME' symbols could be singular or could be used in combination with an additional symbol. A combination of 'MMA' would denote the time frame of 9:31 AM through 2:30 PM. While a combination represented by two symbols separated by a slash denotes multiple time frames. For example, 'MN/E' would indicate a time of 7:00-9:30 AM and 5:01-8:00 PM.

Table 3.3 Attribute Time Frames

Symbol	Time of Day
MN	7:00-9:30 AM
MM	9:31-12:00 AM
A	12:01-2:30 PM
MA	2:31-5:00 PM
E	5:01-8:00 PM
LE	8:01-12:00 PM
AM	12:01-7:00 AM
ALL	24 hours of day

Route attribute tables are displayed similarly to location attribute tables. An abbreviated sample route attribute table is located below (Table 3.4).

Table 3.4 Sample Route Attributes

FENAME	TIME	TRIPS	RTIME	RTYPE	Monday	Sunday	RID
Perkins	.233	4.000	MAE	L	Y	N	CS1
Highland	.033	8.000	EAM	D	N	Y	CS2

The following table (Table 3.5) defines route attribute categories used in the GIS.

Table 3.5 Route Attribute Categories

Attribute	Definition
FENAME	the road name of a given route
TIME	Time is recorded in hours
TRIPS	the number of days a portion of a route was traveled
RTIME	the time of day that the route is utilized to and from each location, symbols in RTIME are identical to those in the location attribute ‘LTIME’ (see Table 3.3)
RTYPE	The type of route. The symbols used in ‘RTYPE’ are identical to those used in the location attribute ‘LOCTYPE’
Days of the week	‘Y’ or ‘N’; ‘Yes’ or ‘No’, denotes if the hypothetical victim traveled or possibly traveled on the corresponding route on a given day.
RID	Unique route identifier

Route and location attribute tables were organized with similar attribute categories and definitions. This allows for straightforward comparison between route and locations attribute data. After the data were imported into the GIS, similarities in multiple hypothetical victims’ activity areas were examined. This was accomplished by overlaying the data from each hypothetical victim. The combined route and location information was then buffered to reflect the geographic concept of distance decay. Distance decay is “the reduction of activity or intersection as distance increases”

(Brantingham & Brantingham, 1981, p.30). Buffering allows for the capability to estimate the likelihood that interaction between a serial killer and the victim occurred at a given location. As the distance from each location increases, the likelihood that the interaction occurred at the location decreases. In this case, four buffers of one hundred meters were placed around each location. Buffering the location data provided a visual method of examining the concentration of multiple hypothetical victims' activity space.

This method and resulting GIS results were evaluated by a veteran Baton Rouge homicide detective, Lt. Karl Kretser. Lt. Kretser has ten years of experience as a homicide detective as well as participation in numerous homicide and forensic courses offered by the Federal Bureau of Investigation and the U.S. Secret Service. The questions asked of the hypothetical victims as well as the resulting GIS information were offered. Results of this discussion are presented in Chapter 5.

CHAPTER 4: RESULTS AND DISCUSSION

A comparison of survey results from the victims of this study and their associates shows evidence that victim activity areas can contribute to serial killer investigations. The ability of GIS to quickly and easily display the data in map form allows the investigator to focus attention on specific locations and geographic areas.

Results of this study show that a considerable amount of a victim's day-to-day routine can be recreated and displayed in a GIS (Figure 4.1).

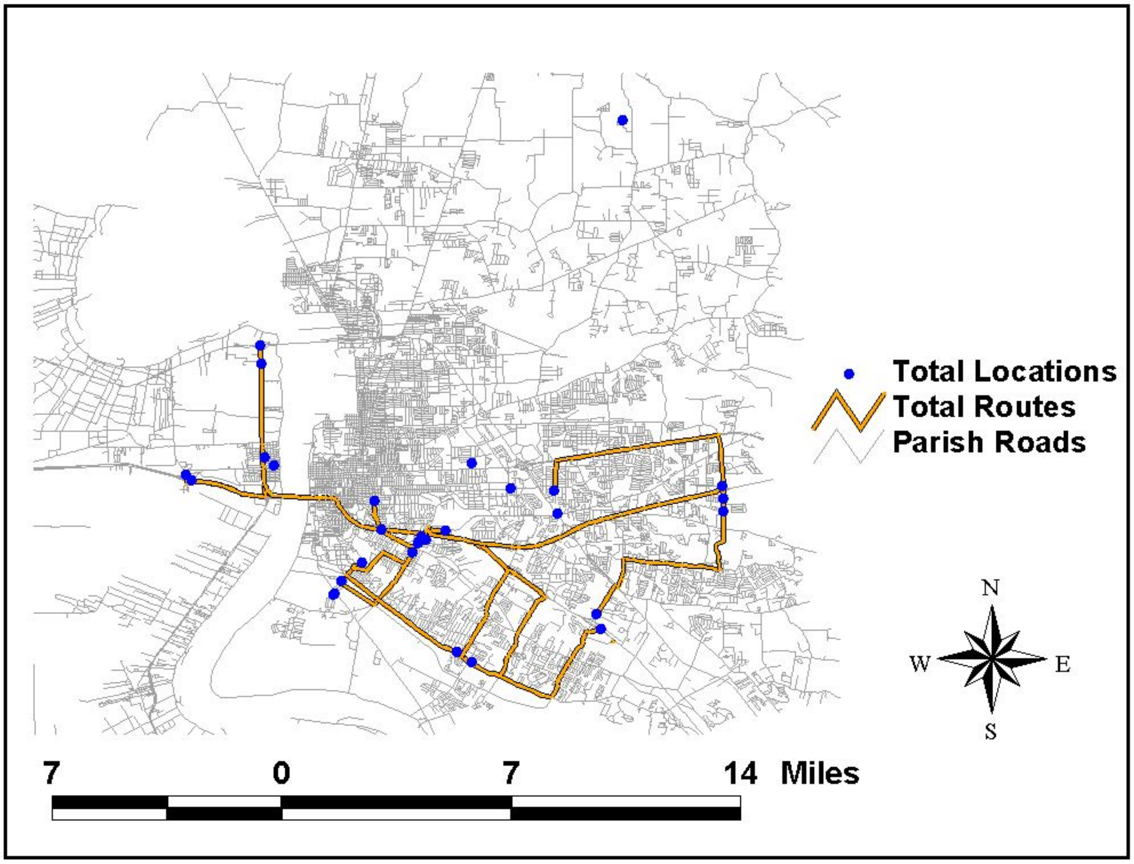

Figure 4.1 Total locations and routes that were identified and mapped in the GIS

In this study, a total of 47 locations and 27 routes were mapped. 'Total' locations and routes are all locations and routes identified by the associates of the hypothetical victims. If multiple associates identified a similar location, it would be displayed only once in the map. Because this is a GIS, the graphic displays are much more detailed and vivid than figures displayed for text discussion. Any combination of the attributes could be queried and a resulting map displayed and further analyzed. A complete table of results is displayed in Appendix B.

When considering the most probable person to question regarding a person's day-to-day activities, the data indicate that friends of a victim have more correct time, location, and route information than parents and coworkers (Table 4.1).

Table 4.1 Total Correct Locations and Routes with Associated Time

	Friends	Family	Coworkers
Total Correct Locations	12 (50%)	9 (60%)	6 (75%)
Total Correct Routes	10 (50%)	3 (50%)	1 (100%)
Total Time in Correct Locations (hrs.)	414.02	124.00	198.00
Total Time in Correct Routes (hrs.)	68.97	2.73	0

The data from this study show that multiple associates of the same victim could assign the same location and route to a hypothetical victim, increasing the probability that the hypothetical victim utilized the route or location. In this case, the hypothetical victim's route and location information was known and all data were verified for accuracy.

For the three hypothetical victims, multiple associates similarly identified nine of the locations and two of the routes. Encouraging results came from one of the associates of a hypothetical victim who correctly assigned a total of 289.63 hours out of a possible 720 hours in a month. If one considers that the average American gets seven hours of sleep a night (WB&A, 2002), the possible hours drops to 510. This assigned amount accounts for 58% of the hours in a month, leaving a limited time for other activities. On a daily basis, a limited amount of time for other activities is equivalent to a limited geographical distance that he could travel to participate in other activities. This is important because it condenses the geographical area where investigators could focus their search for the killer or potential victims.

In all cases, associates of the hypothetical victims correctly identified days or potential days that a hypothetical victim visited a site or route. The associates of the hypothetical victims assigned one hundred and thirteen days correctly out of one hundred and twenty six potential days. Specifically, one location was shared between hypothetical victims (Figure 4.2). For the shared location, two days of the week and a two and a half hour time frame were mutual. The specificity of this example is exactly what could easily be displayed using GIS in such an application and highlights the potential investigative power of the addition of time to geographic profiling. A crime not only occurs at a geographic location, but it occurs in time.

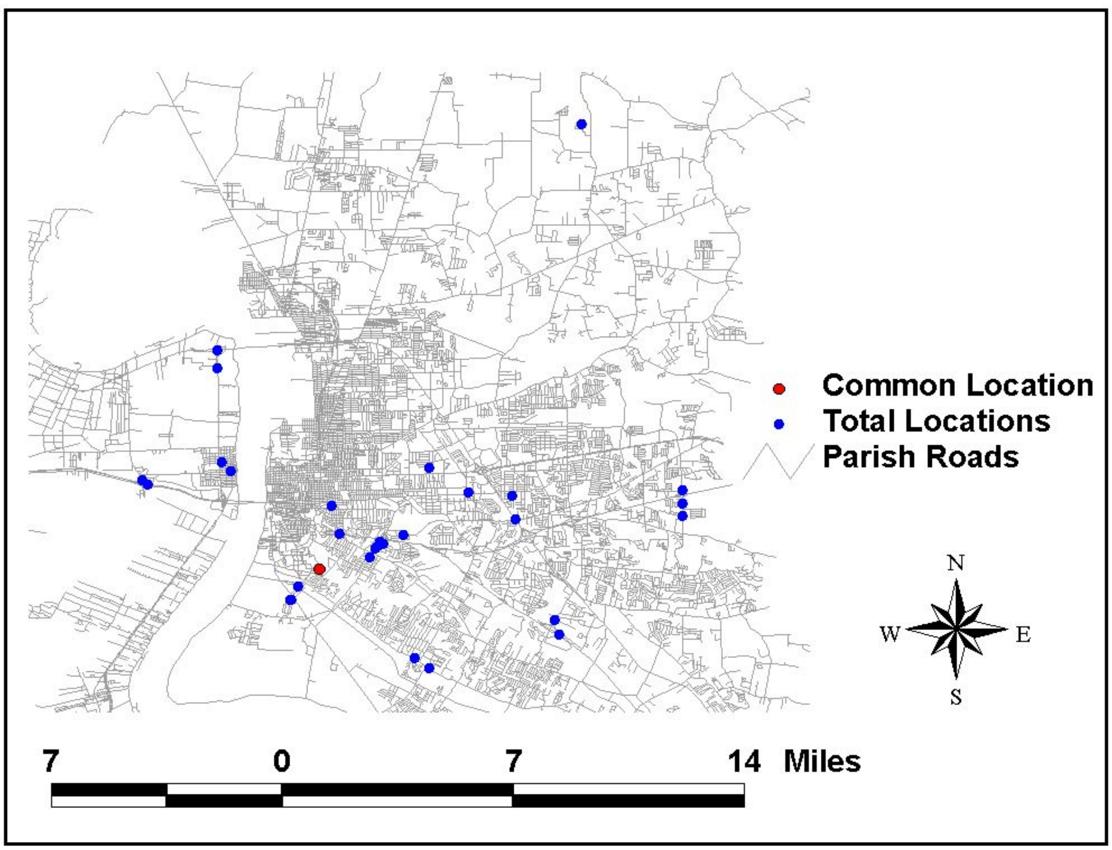

Figure 4.2 Total locations and a location identified as common to multiple victims

A total of seven segments of routes were common between hypothetical victims (Figure 4.3). In addition to location information, common route information helps define the awareness space of the serial offender. The identification of routes common to multiple victims focuses investigation strategies to these geographic areas. Any location along common routes and at common route intersections could potentially be a killer-interaction site or could provide the investigator with additional information regarding the crime.

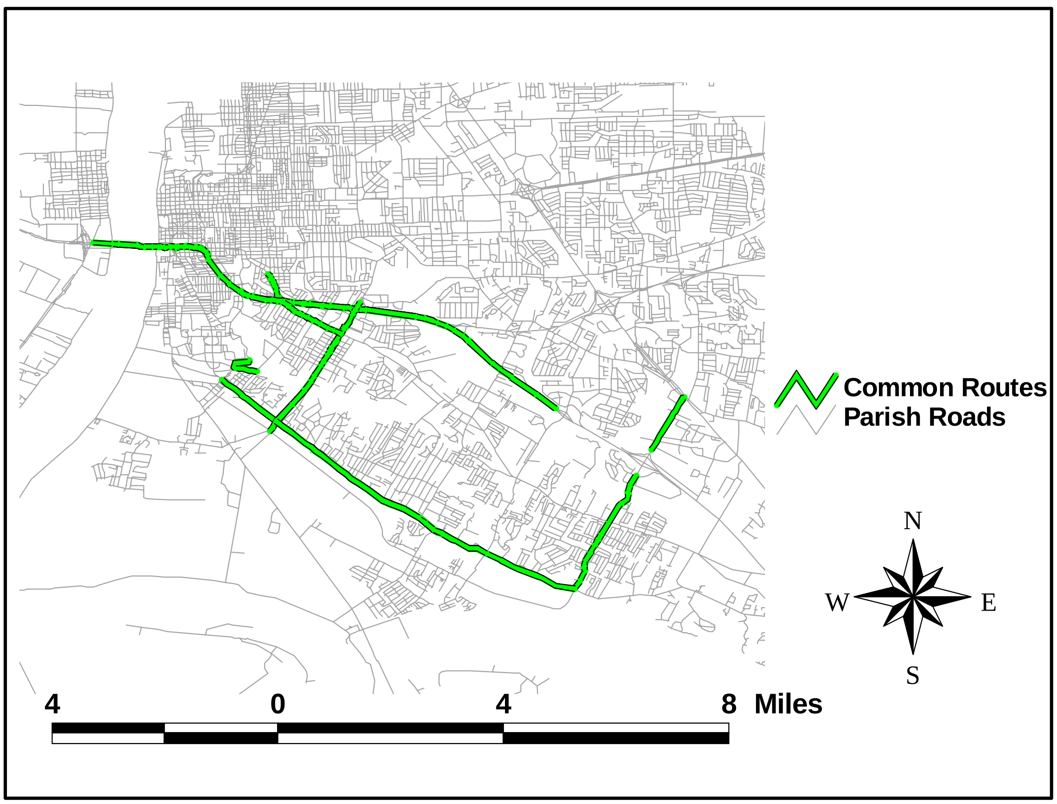

Figure 4.3 Routes common to multiple victims

Use of the 'Model Builder' extension of the Arc View® software allowed for the combination of multiple hypothetical victims' route and location information. The 'Model Builder' extension permits distance buffers to be created around location points and routes. These buffers reflect the geographic concept of distance decay. If any one of the mapped locations was indeed a killer-victim interaction site, the chance that the interaction took place at that location decreases as distance from the point increases. This concept is illustrated by the use of buffers in the visual display (Figure 4.4).

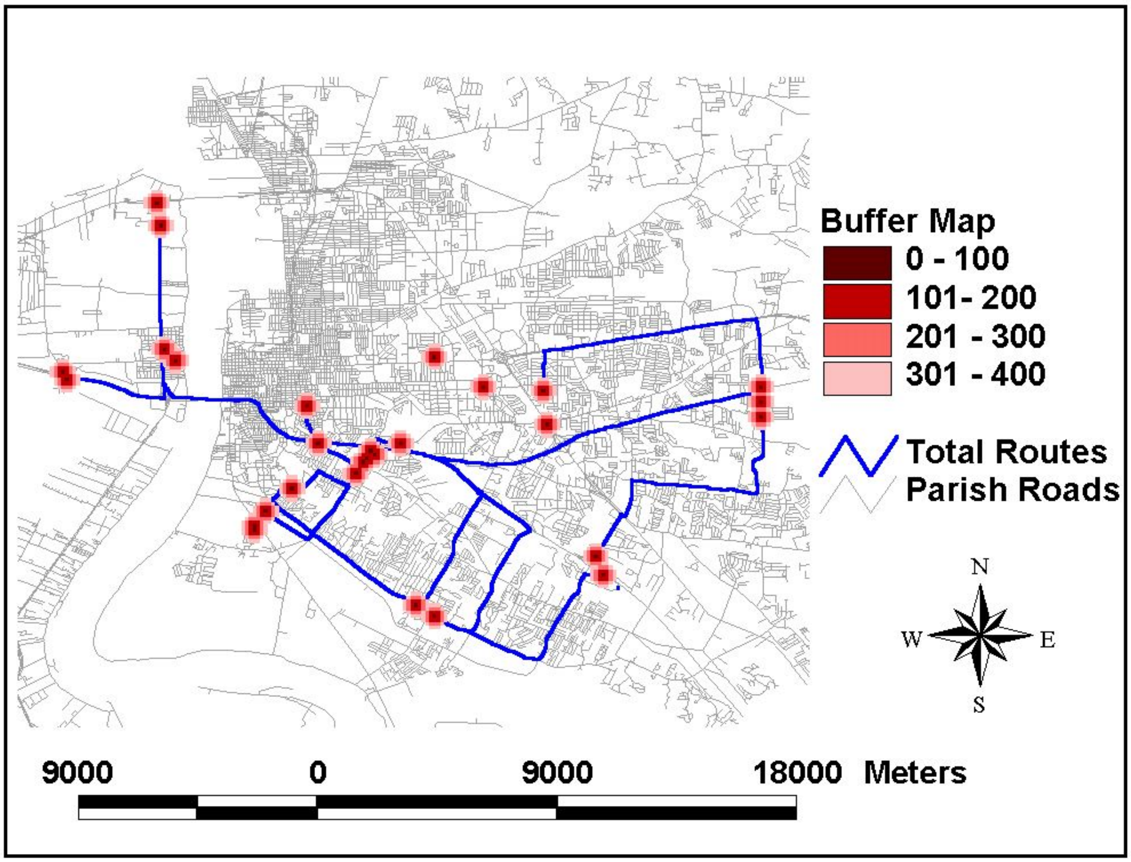

Figure 4.4 Map of buffered locations

In Figure 4.4, location points were buffered using 100-meter intervals. Areas within the buffered area would likely provide more information pertinent to the investigation than areas outside the buffer. The ability to point and click on a location within the buffer would result in a physical address. Homes and businesses represented by the physical addresses in question could then be added to the investigators listing of places to search for additional information regarding the crime in question. Additionally, aerial photographs could be added to the display to further delineate areas of interest to the criminal investigation.

The use of buffers in this model also produced multiple areas of concerted activity. The buffer display highlights areas that concentrations of activity occurred between multiple victims (Figure 4.5).

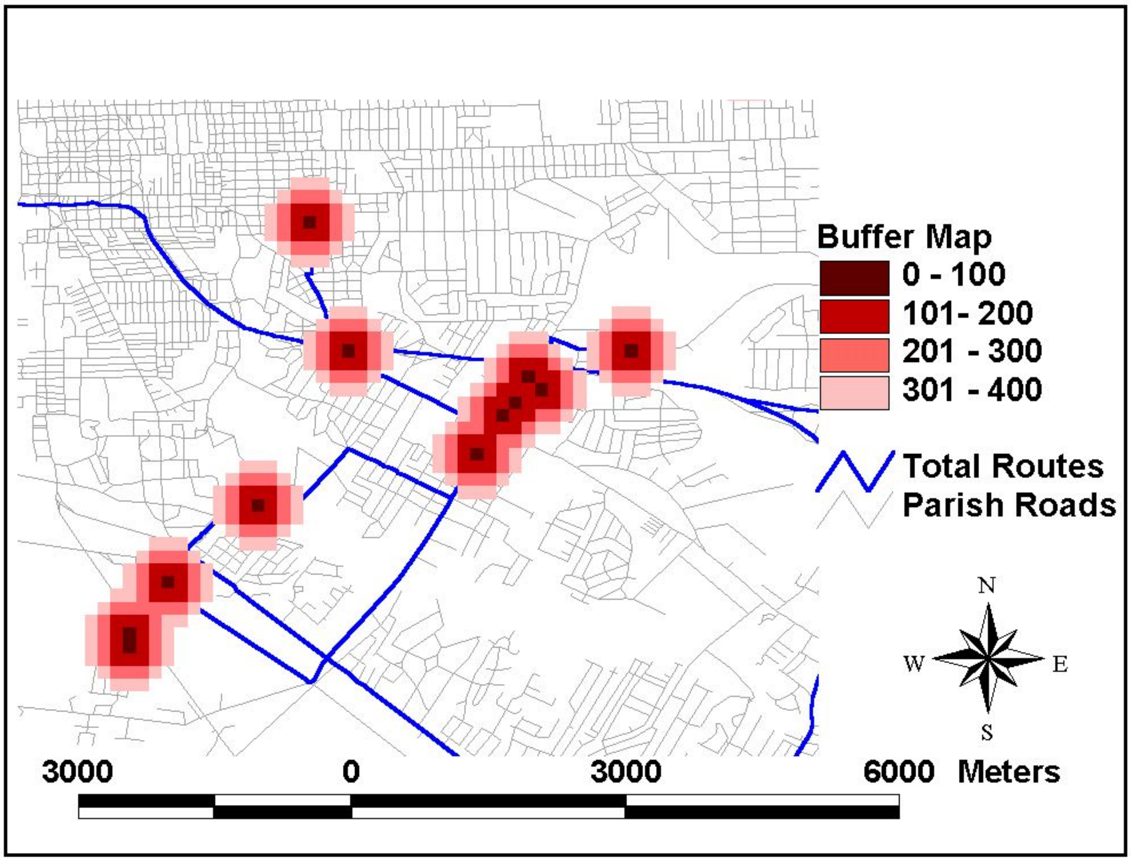

Figure 4.5 Buffer map displaying areas of concentrated activity shared by hypothetical victims

Serial killer investigations inherently accumulate a large amount of data for investigators to analyze. The use of buffer displays in the investigation emphasizes areas in the geography of the crime where multiple victims share activity space and simplifies the large amount of data into a visual display.

The data suggest that people are less active during the first days of the week compared to later in the week. The data collected show that less travel to locations occurred on Monday, Tuesday, and Wednesday than the remaining days of the week. Associates of the victims assigned sixty-two percent (62%) of travel to locations on Thursday, Friday, Saturday, and Sunday. This could be a reflection of the questioning technique. The questions were given exactly as shown in Appendix A. To potentially increase accuracy about specific days, the questions could be asked pertaining to specific days only. The associates of the hypothetical victim could take the investigator through each individual day of the week, focusing on a single day rather than on a usual week or person's general routine. Specificity about certain days could be important to revealing information. Specific questions regarding day-to-day activities are a necessity but still may not be equivalent to ample information. A solution to this problem in the questioning technique is the use of multiple informants and re-interviews, but this was a limit of the research design for this project.

It would be impossible to reconstruct a victim's day-to-day routine with one hundred percent accuracy. There will be gaps in time that are unaccounted for. By applying other methods used in geographic profiling, such as distance measures in an offender's journey to crime (Kent 2003), one could show how far a person could potentially travel in any given time frame. An example taken from the data of this study illustrates this concept. A hypothetical victim was known to work on Tuesday from 9:00 AM until 5:00 PM. Every Tuesday, the hypothetical victim was also involved in a billiards tournament at a local bar from 8:00 PM until 12:00 PM. In the three hour time period between these two events, the hypothetical victim was known to make a trip home. Assuming the hypothetical victim did not report to the billiard tournament at 8:00 PM, due to interaction with the killer, the time frame in question would be from 5:00 PM until 8:00 PM. By applying a distance measure to this three-hour time frame, a geographic distance estimate could be made regarding the distance the hypothetical victim could have traveled from work in that three-hour period. This area could be further condensed if a roommate at the hypothetical victim's residence was able to verify when the victim returned home. The time frame would then be from when the victim left his residence until 8:00 PM and a distance measure from home could be calculated for this time period.

Potential travel distance of the victim of a serial killer allows the investigator to delineate geographic areas that would be of no use in the search for the killer. Rather than focus time and resources on a geographic area that is of no importance, the investigator would be able to explore geographic areas relevant to the investigation. The ability of the GIS to display potential travel distance of a victim again highlights the importance of the element of time in the geographic profile of victims of serial murder. Without the element of time, this potential investigative tool would be ineffective.

Re-creation of the day-to-day activities of a victim also aids in defining a killer's mental map. Mental maps are created using an individual's awareness space as a condition. Brantingham and Brantingham (1981) propose that offenders target victims within their awareness space. By re-creating the day-to-day activities of multiple victims of serial murder and identifying common times, routes, and locations, the 'mental map' of a serial killer is identified. This is displayed visually in the GIS using buffer models of the total routes and activity areas of victims and models of shared routes and locations between victims of serial murder.

Environmental criminology suggests that criminals use physical and social aspects of the environment as a template to access and identify potential targets (Brantingham and Brantingham, 1984). All information from known killer-victim interaction sites could be used to refine the search for potential victims and identify prospective interaction sites. In order to identify potential killer-victim interaction sites, data could be added to the GIS. By correlating victim demographics with the demographics of potential victims, future killer-victim interaction sites could be identified. Additional data layers could also be added to refine the search for killer-victim interaction sites based on the physical information from past victims and database information available for use in GIS programs.

At this point into the investigation of victim activity areas and GIS, it is presumptuous to say that this method could function as a method of serial killer investigation. This is due to limited amount of data in this study and the fact that it has not been tested with actual serial murder data. Rather, this study affirms that such a method should be pursued.

The use of victim activity areas and GIS provides investigators of serial homicide an additional method of analyzing the large and complex amount of information that serial homicide cases incur. This study illustrates that an accurate re-creation of the day to day routine of a hypothetical victim could be obtained. Additionally, the ability of the GIS to organize and synthesize a large volume of route and location information that would be necessary in this type of investigation is modeled. Refinements to future investigations into the use of victim activity areas in geographic profiling are also presented.

This method also shows merit because of its inclusion of time. The addition of time more accurately represents individual activities of people in time and space (Hagerstrand, 1970, 1973, 1978). Time is an essential component for mapping crime with regard to law enforcement applications and is absent in other geographic profiling methods. The work of law enforcement is generally organized into shifts (Harries, 1999). Because shift work inherently divides the day into different time frames, the ability of the GIS to present data in regards to certain time frames is important. Different types of maps that reflect changes in data throughout the day could be produced for different shifts of the day.

Existing geographic profiling systems have been questioned for their ability to effectively contribute to serial offender investigations (Gore & Tofiluk, 2002; Snook, 2000). As new methods that include more theoretical content such as time, demographic data, and socioeconomic environment, are developed, the understanding of crime patterns in mapping will improve (Harries, 1999). Without contextual information, investigators risk focusing only on the crime pattern and missing associated underlying processes.

Recognizing that this method and resulting GIS had not been evaluated by an actual member of the law enforcement community, this project was presented to a veteran homicide detective. Important contributions, suggestions, and validations of ideas presented in this thesis are offered in the subsequent chapter.

CHAPTER 5: LAW ENFORCEMENT PERSPECTIVE

This method and resulting GIS was presented and evaluated by a veteran Baton Rouge sheriff's deputy. Insight into potential real-world application of this method was evaluated for feasibility and suggestions for further refinement of this method were offered. The evaluation resulted in a number of ideas and proposals. The resulting ideas and proposals are listed herein:

1. A victim's mobile phone use could offer day-to-day location information.
2. Listing a victim's day-to-day clothing as an attribute in the GIS is important.
3. The day-to-day routine is not restricted to activities away from the home.
4. Best friends have the largest volume and most accurate day-to-day routine information followed by family members.
5. Coworkers have limited day-to-day information outside of the workplace, unless the persons are friends or they have worked together for a long period of time.
6. The re-creation of a prostitute's day-to-day activity is very difficult.
7. Physical address information of acquaintances should also be included.

The ideas presented by the homicide detective provide an important addition to future refinements to this method. In the re-creation of a victim's day-to-day routine, the accumulation of mobile phone records could provide the most time and location information. Not only do mobile phone companies provide the time, duration, and number phoned in each call, mobile phone companies have the capability to trace each call to a general geographic location through global positioning technology. The geographic locations provided by mobile phone records would provide additional data to the GIS. Mobile phone records could also be used to verify data solicited from associates of the victim for accuracy. The amount of temporal and geographical data provided by mobile phone records would be proportional to the victim's cell phone usage. Today, global positioning technology is also available in many automobiles. Mobile phone records, as well as the records of GPS capable automobiles, have the potential to impact the re-creation of a victim's daily routine and contribute to a serial killer investigation immeasurably.

The suggestion to include questions about a victim's day-to-day routine around the home would refine the questioning technique used in this study. People often leave their house without going to another location for such reason as to get the mail, take out the garbage, and mow the lawn. Routinely, these activities happen on specific days and at a certain time of day. The amount of time that the victim spends at home should also be considered in the questions posed to associates. The addition of routine activities around the home and time spent at home are viable additions to the questions developed for this study.

The proposal that best friends have the largest volume and most accurate information followed by family members is supported by what was found in this study (Table 4.1). The suggestion that coworker information is dependent upon the coworker relationship and employment duration could be a reason that coworkers had such limited information in this study. Forming a list of acquaintances and their corresponding home addresses of the victims of serial murder would add additional information to the GIS that could be correlated to known routes and locations of the victim. Acquaintances that lived on or near a route or near a location could be visited by the victim during travel. These locations could be useful if the victim traveled to the acquaintances home during unassigned periods of time.

The additional information provided by the law enforcement officer provides valuable insight into future applications of a geographic profile of victims of serial killers. Because of the source of these proposals, the inclusion of the suggestions into future refinements of this method is necessary to provide validity to such a method.

CHAPTER 6: CONCLUSION

This provisional examination of the utility of victim activity areas in the geographic profiling of serial killers resulted in data that support further examination into such a method. Through the development of this method, new approaches to and refinements of this method were realized. This new method demonstrates that, instead of costly spatial analysis software used today in geographic profiling, geographic information pertinent to a serial killer investigation can be disclosed using a commercial GIS.

The use of a questionnaire to reveal day-to-day information of the hypothetical victim provided an abundance of data. Route and location data were verified for consistency based on the hypothetical victims responses to the same questions. In an actual serial killer case, the victim would not be able to verify the precision of the responses that his associates made regarding his daily routine. Rather, this study provides information as to who would have the most accurate day-to-day activity information. Friends were identified as having more correct information regarding the day-to-day routine of the hypothetical victim than family or coworkers. The experienced homicide detective also confirmed that friends, specifically best friends, have the most relevant daily routine data. However, caution should be observed to not isolate those who are defined as 'best' friends as this term is subjective and all friends could provide important data. These data could enable a serial killer investigator to prioritize his search for associates of the serial killer victim.

The questioning technique used revealed deficiencies in such an approach. In this study, questions were asked of the associates of the victim regarding the victim's general routine, primarily the workweek. Rather, focus should be on asking questions beginning with the first day of the week and following each day through the end of the week. One could even break each day into time intervals and ask the associate what the hypothetical victim was doing during specific intervals. Additionally, questions regarding routine activities around the home, such as getting the mail, mowing the grass, or taking out the trash were overlooked.

Improving the specificity of the questionnaire would also lead to a higher degree of temporal accuracy in the GIS. For this study, the day was broken up into roughly three and a half hour time frames and categorized as such in the GIS attributes. In order to increase temporal accuracy, a daily questionnaire with distinct time intervals should be applied. Additional geographical and time data provided by the victims' cell phone records would also increase the likelihood of identifying common activity areas between multiple victims.

Associates revealed information that was consistent with the information provided by the hypothetical victim himself. The consistent data were then modeled in the GIS. Actual serial killer data would not be able to be verified for accuracy with the victim. Rather than dismiss data that were particular to one associate of the victim, layers of consistency in the data could be modeled in the GIS. Accuracy of the data could be assigned based on the number of associates who revealed similar information about the victim. This accuracy in the data could then be reflected in different data layers in the GIS. Overlaying the data layers in the GIS would then produce a complete geographical visualization of the victim's activity areas with areas of higher probability of activity being emphasized.

Existing geographic profiling systems are designed to identify the location of the serial offender's residence. The identification of serial killer-victim interaction sites was examined in this thesis using commercial GIS software. Results of this study show that the day-to-day activities of a hypothetical victim of serial murder can be recreated and analyzed for similarities. The geographic visualization and associated data produced by the GIS highlighted similar activity areas of multiple victims. These data provide the investigator of serial murder a geographic and temporal focal point in their search for a serial killer. The resulting data also offer insight into identifying future killer-victim interaction sites. The flexibility of the commercial GIS to add and query an unlimited amount of data categories in the GIS enables future applications of this method to be restricted only by the investigator's resourcefulness.

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APPENDIX A
SURVEY QUESTIONIARRE

Along with the responses, time spent on each route (particular 'legs' of the route) or at each location must be documented. A map of the area in question should also be supplied.

The Work Day (family/friend)

What time did (name) leave the house?

What route did (name) take from home to work?

How set was this route? (variations for traffic?)

Did he make any regular stops along the way? (coffee, etc.?)

When did (name) leave for work?

What route did he take?

How set was this route? (variations for traffic)

Did he make any stops (irregular or regular) along the way?

2. Coworkers

Where did (name) take his lunch?

What time did (name) leave for lunch?

What were regular lunch locations (at least once every two weeks)?

What was the usual route taken to each lunch location?

How set was the route (variations due to traffic)?

Did he have any other lunch time stops (gym, bank, etc)?

Did the job involve any regular travel during work hours (delivery, etc)?

What time did the (name) usually leave for these trips?

What was the destination?

What was the usual route taken?

How set was this route? (variations for traffic)

What was the usual time for leaving work?

What was the route taken?

How set was this route? (Variations for traffic)

Did he make any stops (irregular or regular) along the way?

3. Social Habits (family/friends)

What type of hobbies or regular social activities did the victim have (running, cycling, dancing, coffee shops, classes, shopping, sporting events, happy hours, favorite dinner spots, clubs, sports, etc.)?

Do any of the hobbies or regular social activities involve travel, even if it was a short distance?

What time did (name) leave the house?

What route did the victim take from home to the activity?

How set was this route? (variations for traffic?)

Did he make any stops (irregular or regular) along the way?

Did this hobby or activity include a set path within the event itself (running, jogging, cycling, etc)?

Where did (name) acquire his daily necessities (groceries, gas, bank, dry cleaning, laundry, shopping)?

How often did (name) visit each location?

What route did the victim take from home to the activity?

How set was this route? (Variations for traffic?)

Did he make any stops (irregular or regular) along the way?

How often did (name) visit their parents?

APPENDIX B
SURVEY DATA

Primary Contact: R Locations/Routes ID	Total Time in Locations	Total time in Routes	
10	237.824 hours	20.762 hours	

	R Friend	Rparent	Rcoworker
Total Locations ID	6	10	2
Total Routes ID	5	5	0
Routes UNK	1	2	0
Locations Consistent	4	4	2
Locations Inconsistent	2	1	0
Routes Consistent	3	2	0
Routes Inconsistent	2	1	0
Total Time Con. Loc.(Hrs.)	165.32	112	0
Total Time Incon. Loc.	2.5	0	0
Total Time Con. Route	7.204	1.528	0
Total Time Incon. Route	4.134	0.4	0
Loc. Days Consistent	27/28	22/28	0

Primary Contact: M Locations/Routes ID	Total Time in Locations	Total time in Routes	
9	272 hours	38.969 hours	

	M Friend	M Parent	M Coworker
Total Locations ID	11	4	4
Total Routes ID	9	0	1
Routes UNK	2	4	3
Locations Consistent	4	3	3
Locations Inconsistent	7	1	1
Routes Consistent	4	0	0
Routes Inconsistent	5	0	0
Total Time Con. Loc.	233.2	0	198
Total Time Incon. Loc.	47.25	8	6
Total Time Con. Route	56.433	0	0
Total Time Incon. Route	7.891	0	0
Loc. Days Consistent	26/28	17/21	21/21

Primary Contact: J Locations/Routes ID	Total Time in Locations	Total time in Routes	
12	224.336	35.04	

	J friend	J Parent	J coworker
Total Locations ID	7	1	2
Total Routes ID	6	1	0
Routes UNK	1	0	2
Locations Consistent	4	1	2
Locations Inconsistent	3	0	0
Routes Consistent	3	1	0
Routes Inconsistent	3	0	2
Total Time Con. Loc.	15.5	12	0
Total Time Incon. Loc.	12.834	0	0
Total Time Con. Route	5.328	1.2	0
Total Time Incon. Route	5.679	0	0
Loc. Days Consistent	27/28	7/7	13/14

VITA

Casey Shamblin was born and raised in Chattanooga, Tennessee. Casey earned his Bachelor of Arts degree in anthropology from the University of Tennessee in 1999. Leaving the hills of Tennessee in 2001, Casey ventured to the flatlands of Louisiana to pursue his master's degree at Louisiana State University. While at Louisiana State University, Casey worked as a graduate student in the FACES lab and presented a paper at the annual Academy of Forensic Sciences meetings in Chicago, Illinois. Additionally, Casey joined the United States Army and will be commissioned as an officer in Military Intelligence upon graduation. Casey currently works for the Louisiana Office of Homeland Security and Emergency Preparedness and plans to pursue a career in the federal government.